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The Bermuda Rise has been a site of sustained paleoceanographic and sedimentological investigation due to its strategic location and the high sediment accumulation rates that characterize this drift deposit. Recently, we have established that fine-grained sediments which serve as the diluent entrain allochthonous organic matter and influence corresponding molecular proxy signatures. In an attempt to further understand the advective processes that lead to spatial and temporal offsets between molecular and microfossil records at this site, as well as their links to past climate variations, we examined in detail down-core molecular and bulk properties spanning the last glacial maximum to the present. We observe strong correspondence between age offsets and sedimentology, and these in turn are linked to known climate perturbations. Possible causes for these relationships are discussed in terms of sources and modes of delivery of fine-grained sediments to the Bermuda Rise, as well as implications for the application of multi-proxy records.

PP51C-0939 0830h POSTER

Beringian Sea Level and Marine Climate History: Investigations into Regional & Global Impacts

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Glacial-interglacial cycles have imposed on the Bering Strait region some of the most radical changes in paleogeography documented in the Northern Hemisphere. Only 20,000 years ago during the last glaciation when sea level was about 130 m below present, the Bering Land Bridge separated the deeper Bering Sea and North Pacific Ocean from the Arctic Ocean by more than 1000 kilometers of herb-dominated tundra. Missing from existing literature are studies of how the Bering and Chukchi seas participate in controlling Beringian and global climate. Fluctuations in sea level caused the rapid migration of shorelines changing gradients in temperature and moisture with considerable downwind effects based on regional terrestrial records. The greatest east-west heterogeneity across Beringia occurred during warm (flooded) or warming (partially flooded) periods of late Pleistocene summers, when the cool maritime influence bifurcated the relatively warm continental interior. Oceanographic changes were also radically influenced by changes in sea level across the Bering Straits that regulated the northward flow of Pacific waters into the Arctic Ocean and North Atlantic. Especially important in our collective research is an understanding of how the flow of water through the Bering Strait may have influenced documented changes in thermohaline circulation in the North Atlantic (e.g., Younger Dryas) by changing the flux of fresher Pacific water into the Arctic Ocean. On board the USCGC Healy in the summer of 2002, we collected from -2800m to -50 m water depth, a set of nearly 100 different marine cores measuring over 500 meters in total length. Some are up to 21 meters long, from -1300 m water depth, the longest cores taken in this part of the western Arctic. Specific cores appear to hold a high-resolution record of the deglacial and Holocene history in this region and a few of the cores likely contain sediments back to nearly 140,000 yrs BP. We also learned that the stratigraphic architecture of channel cut and fill across the Chukchi shelf is very complex with an outstanding record of repeated phases of sea level rise and fall. This complexity and related paleoceanographic implications will likely drive the direction of our future research. A series of related posters in this session highlight initial results from this ongoing project.

PP51C-0940 0830h POSTER

Climate Controlled Changes in Deep Ocean Flow: Examples From the Riiser Larsen Sea (Antarctica) and the Fram Strait (Arctic Ocean)

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Sediment cores from the northeastern Fram Strait (Arctic Ocean) and the western Riiser Larsen Sea (Antarctica) were investigated to reconstruct climate forced fluctuations of bottom currents. In terms of global water-mass circulation, the Arct ic Ocean plays a rather passive role with only very limited deep-water exchange through the Fram Strait. The cores investigated here are primarily influenced by the Yermak Slope Current (YSC), a water mass that is mainly composed of NSDW. Since NSDW is fo rmed in the Greenland Sea as a result of deep-water production, it is suggested that fluctuations in the speed of the YSC are linked to fluctuations in thermohaline overturn which in turn is strongly related to climate development. It turns out that cold events s uch as the Younger Dryas (12.7-11.5 kaBP) were periods of lower bottom-current speed whereas warmer periods suggest increased bottom-current activity. Holocene climate phases such as the cold "8,200 year Event" left clear traces in the record. In the Ri iser Larsen Sea that forms the easternmost part of the Weddell Gyre, deep-current controls are different. A large system of channels on the continental slope suggests that the channels are active pathways of either dense shelf waters or turbidity current s. Long sediment cores recovered from levees that flank the channels reveal carbonate-rich sediments with few IRD during the interglacials and carbonate-depleted sediments during the glacials in the sand f raction. High resolution granulometric data suggest that the channels were more active during interglacials than during glacials. In glacial climates surface-water bio-production in the RLS was low. Presumably a quasi-permanent ice cover prevailed that al so prevented the deposition of IRD. During interglacials conditions were like those of today with a very large sea-ice cover in winter and open water conditions in the austral summer. It can be assumed that dense water formation on the upper continental slope is reduced during the glacials and somewhat higher during interglacials.

PP51C-0941 0830h POSTER

Changes in Benthic Foraminiferal Assemblages and Total Organic Carbon in Sediments at ODP Site 1058, Blake Outer Ridge During Marine Isotope Stages 11-12

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Marine isotope stages 11-12 (approximately 480 to 362 ka) comprise the most extreme climatic and hydrologic changes of the Late Pleistocene. During MIS 12, sea level was about 140m below present, and the production of NADW was severely reduced. In contrast, MIS 11 was probably the warmest and longest interglacial of the last 500 kyrs, characterized by sea level possibly 20m higher than today and a maximum in NADW production. In the western North Atlantic, the switch from one mode of circulation to the other appears to have been paralleled by a 3-4°C change in bottom-water temperatures. We have examined benthic foraminiferal assemblages and organic carbon content in sediments from ODP Site 1058 (Blake Outer Ridge, 3000m water depth), spanning the MIS 11-12 time interval. Stable isotope data indicate that during MIS 11 Site 1058 was bathed by NADW, and by a water mass of southern origin during MIS 12. The organic carbon record is characterized by elevated values in the early part of MIS 11 and at the end of MIS 11. Benthic foraminiferal assemblages in these intervals show increased abundances of Bulimina, Uvigerina and Melonis, taxa usually indicative of stressed environments. The overall benthic foraminiferal record shows changes in relative abundances of the different taxa that are not related simply to glacial-interglacial changes. Instead, a more complex variability is evident, driven most probably by the interplay of different environmental factors, including changes in current strength and food supply, downslope transport, and lateral advection of material reworked from shallower areas.

PP51C-0942 0830h POSTER

Neodymium Isotopic Composition of Terrigeneous Sediment as a Monitor of Bottom- and Surface Currents: an Example From the Fram Strait

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A high resolution sediment core from the northeastern Fram Strait (Arctic Ocean) was investigated to reconstruct fluctuations of bottom- and surface currents related to climate change during the Late Quaternary. Neodymium isotopic compositions were determined for four different grain size fractions (<2 μm, 2-10 μm, 10-63 μm, >63 μm) of 17 samples covering the last 130 ka. These grain size fractions are assumed to monitor different transport mechanisms such as current transport and ice rafting. The neodymium isotopic composition of terrigeneous sediment is not affected by grain size variations or uptake of dissolved neodymium from sea water, and therefore reflects the isotopic composition of the source rock. This can be used to trace sediment pathways. The neodymium isotopic data indicate that sediments deposited at the core location are a mixture of material derived mainly from Spitsbergen and the Lena-, Ob-, and Yenisei Rivers (Siberia). Variations of the isotopic compositions with time reveal variable contibutions of the source areas as a result of changed oceanographic conditions. Only relatively small isotopic variations are found during MIS 3, 4, and 5, whereas major changes of the oceanographic conditions are indicated during the LGM and the early Holocene.

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PP51D MCC: 3004 Friday 1020h

Global, Hemispheric, and Regional Climate Signals During the Last Millennium II *(joint with A, H, C, GC)*

Presiding: **C M Ammann,** National Center for Atmospheric Research**; P Naveau,** University of Colorado

PP51D-01 1020h INVITED

The 1810s as an ideal test of climate model skill in predictability

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One of the goals of paleo-research is to provide better constraints on our ability to understand the causes and consequences of climate change. The 1810s may represent an ideal case for such studies. It was the coldest decade of the last 300 years and climate models suggest that on the hemispheric scale the temperature changes were driven by a linear response to two very large eruptions in 1809 (Unknown) and 1815 (Tambora). Because the large scale can be simulated so well it is of interest to examine the regional response to such

large scale forcing changes, for such a response represents a very useful target for GCM modeling groups to assess skill in regional predictability. An analysis of the Mann et al. data set indicates that the regional response from 1809-1818 was by no means uniform. Peak cooling occurred in eastern North America and the North Atlantic sector. The response in the Pacific sector was relatively mild; the reconstruction for the Pacific Northwest suggest a PNA type pattern associated with an upper level ridge that would account for such warmth and also the severity of the downstream cooling over eastern North America and the North Atlantic. There is also some indication of relatively mild/warm SSTs in the eastern North Pacific. These results indicate that the large circulation response translated the radiative forcing perturbation into one of the dominant modes of the extratropical Northern Hemisphere circulation. Future studies focusing on the GCM response over this interval would provide a valuable test on a model's ability to predict the regional response to future greenhouse gas perturbations.

PP51D-02 1035h

Stochastic simulation of large explosive volcanic eruptions and their impacts on climate

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Externally forced natural climate variability played an important role over a large part of the 20th century. Unfortunately, projections into the future using a host of different scenarios do not include the natural components but focus on anthropogenic elements only. Although anthropogenic forcing is expected to be dominant, the lack of natural variations is a clear deficiency in regard to uncertainty estimates of future climates. In this talk, we focus on the stochastic modeling of volcanic forcing. A probabilistic model that reproduces the occurrences and the climatic impacts of large explosive volcanic eruptions in the tropics will be presented. To reach this goal, we first introduce an automatic procedure that estimates the climatic impact of strong but short-lived perturbations from large explosive eruptions on a variety of multi-proxy temperature reconstructions and output from a coupled Ocean-Atmosphere General Circulation Model. The extraction method based on a statistical multi-state space model provides an accurate estimator of the timing and duration of the climate response to an eruption. This will not only allow for a more objective estimation of the associated peak amplitude (cooling) and the subsequent time evolution of the signal, but at the same time it will provide a measure of confidence through the posterior probability for each cooling event. Secondly, the distribution of the derived magnitudes from these largest volcanic coolings will be shown to follow a Generalized Extreme Value distribution. Because we can estimate all the parameters of our probabilistic model, we will be able to stochastically simulate the occurrences and the magnitudes of future large explosive volcanic events. Such simulations can be used for adding forcing into future scenario runs in climate models. Currently, this external forcing is completely missing in these scenarios.

PP51D-03 1050h

Coherent Signals in Northern Hemisphere Proxy Records Over the Past Two Millennia: Shared Variability and Support for a Warm Tropical Pacific During the Little Ice Age.

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Proxy tree ring, ocean core, and pollen records show a coherent pattern of increased precipitation in California and into the Great Basin, decreased temperatures in the Sierra Nevada and increased sea surface temperatures (SSTs) off Southern California consistent with the recent suggestion of warm tropical Pacific SSTs during the Little Ice Age (LIA)and cool SSTs during antecedent centuries. Low frequency signals coherent with these changes appear in lacustrine records from the central and eastern US, a recent reconstruction of the strength Iceland Low, the Quelccaya Ice Cap d18O record, and SST records from the subtropical Atlantic. We suggest scenarios consistent with this suite of changes in terms of altered circulation patterns. Comparisons between the proxy records and results from a recently completed 1150-year simulation with the NCAR CCSM reveal points of agreement and disagreement. These points support an important role for radiative forcing as a driving force behind low frequency variability during much of the last two millennia, and at the same time suggest that the responses of the actual climate system to such forcing may be larger and more discontinuous than those seen in the model climate.

PP51D-04 1105h

Simulating the Last Half-Millennium

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To test simulated AOGCM variability and change against proxy reconstructions we have simulated the last half-millennium using the HadCM3 model forced with natural and anthropogenic forcings. The natural forcings used were changes in orbital parameters, volcanic aerosol forcings, and solar irradiance. A simulation (NATURAL) forced with only natural factors and with land-surface characteristics set to 1750 values and well-mixed greenhouse gases set to pre-industrial concentrations was carried out. A second simulation (ALL) with both anthropogenic and natural forcings was started in 1750 from NATURAL. In ALL sulphate aerosols, greenhouse gases, ozone and land surface characteristics also change. The natural simulation shows general agreement between the naturally forced simulation and paleo-reconstructions until the mid- to late-19th century. However simulated surface-temperature response to external forcings (largely volcanic) appears to be too large while simulated decadal variability is significantly smaller than that reconstructed. In the simulations there is an anthropogenic impact on climate by the mid to late 19th century. Comparison with early European instrumental data appears to qualitatively confirm the simulated anthropogenic cooling during the 19th century. Simulated sea-level falls rapidly after large volcanic eruptions (such as Tambora) then recovers over several decades to pre-eruption conditions. A simple diagnostic model shows maximum glacier advance during the maunder minimum and the mid-19th century. Twentieth century sea-level rise is dominated by anthropogenic forcings mainly due to thermal expansion with a moderate contribution from glacier retreat.

PP51D-05 1120h

Simulated and Observed Climate Signals in Borehole Temperature Profiles

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Forward simulation of borehole temperature profiles are presented, using ground (soil) temperature variations simulated by the HadCM3 climate model forced by natural and anthropogenic factors from AD 1500 to 2000. Differences between soil temperature and air temperature variations are assessed, in terms of the driving influence of snow cover and vegetation cover changes, and in terms of their impact on the simulated borehole temperature profiles. The simulated profiles are then compared with observed temperature profile anomalies. The sensitivity of air temperature reconstructions to method of gridding the individual borehole records and to the profile sampling date will be demonstrated by analysis of the climate signal in the observed temperature profile data set. Comparison of the spatial signature of twentieth century borehole-derived trends with instrumental air temperature trends is used to assess confidence in the climate signal recoverable from the borehole data set.

URL: http://www.cru.uea.ac.uk/cru/projects/soap/

PP51D-06 1135h

Borehole Climate Reconstructions: Spatial Structure and Hemispheric Averages

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Ground surface temperature (GST) reconstructions determined from terrestrial borehole temperature profiles, when averaged over the northern hemisphere, estimate a surface warming of approximately 1 K during the interval AD 1500-2000. Proxy-based estimates suggest less warming during the same interval. Borehole-based reconstructions have recently been the target of two criticisms. The first emerges from the application of a method for optimal detection of the surface air temperature (SAT) signal in the GST reconstructions, whereas the second focuses on the need for spatial gridding and area-weighting of the ensemble of borehole-based GST reconstructions. The optimal detection method has purported to show only a weak correlation between 20th century trends in the GST and SAT. We examine this issue with an assessment of the sub-hemispheric spatial correlation of GST and SAT trends at various spatial scales. We show that in the five-degree grid employed for optimal detection, the majority of grid-element means are weakly determined from three or fewer boreholes, a number that is insufficient to suppress site-specific noise. Thus most mean GST reconstructions in five-degree grid elements are deprived of signal enhancement through ensemble averaging, and are therefore obscured by unsuppressed noise. Agreement between GST and SAT trends in individual five-degree grid elements increases substantially with the number of boreholes occupying the element. Spatial correlation between SAT and GST improves significantly at larger grid sizes in which grid-element means are determined from many more GST reconstructions. We demonstrate the robustness of GST warming estimates by showing that over a wide range of grid-element area and occupancy weighting schemes, the hemispheric five-century GST change falls in the range of 0.89-1.06 K, a range which includes the estimate of ca.1 K warming determined by simple averaging of the ensemble of borehole-based reconstructions.

PP51D-07 1150h

A Northern Hemisphere Climate Reconstruction through Integration of Borehole Temperature Data and a Conventional Proxy Model

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Each disciplinary approach to a paleoclimate reconstruction has its own strengths and limitations in representing past climate variability. A reconstruction from borehole temperatures is more robust in detecting long-term variability than in retrieving high-frequency information. Conversely, a reconstruction from a traditional proxy approach usually offers a higher temporal resolution of relative changes along with a greater uncertainty in the long-term trend. Aided by a controlled simulation Zorita et al. (2003, J. Clim., v.16: 1378-1390) show that the technique employed by Mann et al.

(1999, Geophy. Res. Lett, v.26: 759-762) for climate reconstructions can represent annual climate variability reasonably well, whereas it suffers from difficulties in reproducing the low-frequency behavior of the global temperature evolution even under favorable conditions. With annual climate variability captured in high resolution proxies and long-term information preserved in borehole temperatures (e.g., Huang et al., 2000, Nature, v.403: 756-758; Harris and Chapman, 2001, Geophys. Res. Lett., v.28: 747-750; Beltrami, 2003, Science, v.297: 206-207), it is desirable to develop a technique to integrate the two schools of information for a more complete picture of the past climate change. I present such an integrated reconstruction by inverting a composite subsurface temperature profile assembled from 697 boreholes from the Northern Hemisphere, with the annually resolved multi-proxy reconstruction of Mann et al. (1999) as the a priori model. The integrated reconstruction shows a net warming of around 1K and a delineation of two relatively cool periods over the last five centuries. Within the five-century interval the 17th century was the coolest and the 20th century the warmest. Temperatures dipped in the 19th century prior to the 20th century warming. The integration of the two bodies of information greatly improves the comparability of the reconstructed temperatures and the radiative forcing history. Regression analysis of the integrated reconstruction and an ensemble of natural and anthropogenic forcings suggests a greater sensitivity of climate to external forcings than previously estimated.

PP51D-08 1205h

Global Multidecadal to Century-Scale Climate Oscillations During the Last 1000 Years

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The problem we address is the detection, distribution and analysis of quasiperiodic features in the climate system at time scales approaching the length of the instrumental record. There are multiple lines of evidence for the existence of roughly century-scale oscillations in the instrumental temperature record, and in annual-resolution proxy records from many parts of the world. Clearly, the instrumental record of 100-150 years in length is of limited help in identifying and explaining such oscillations. Mann et al. (1995), in a multivariate analysis of a globally distributed set of temperature proxy records of several centuries' duration, produced evidence for persistent natural interdecadal and century-scale climate oscillations. They saw a coherent signal with roughly 50-year period before AD 1650, which got stronger and more significant after that date, drifting into a 60-70 year periodicity in recent centuries. We attempt to place these changing patterns of oscillation in a global perspective for the past 1000 years, using a greatly expanded data set of high quality proxy records. We use approximately 100 existing quality-controlled annual or near-annual resolution proxy records valid for all or most of the last 1000 years. As we are interested specifically in the frequency-domain structure of past climate variability, it is advantageous to use frequency-domain methods applied to the raw proxy data, rather than to climate reconstructions based on time-domain based eigenvector techniques, to elucidate, with greatest fidelity, the frequency-domain structure of any underlying climate. For this reason, we use the Mann et al (1995) MTM-SVD and evolutive MTM-SVD method. Preliminary results confirm and extend the conclusions of Mann et al. (1995). Reference. Mann, Michael E., Jeffrey Park, and Raymond S. Bradley. 1995. Global Interdecadal and Century-Scale Climate Oscillations During the Past Five Centuries. Nature 378: 266-70.

PP52A MCC: Level 2 Friday 1330h

Global, Hemispheric, and Regional Climate Signals During the Last Millennium III Posters *(joint with A, H, C, GC)*

Presiding: **S F Tett,** Hadley Centre, University of Reading**; T J Osborn,** Climatic Research Unit, University of East Anglia

PP52A-0943 1330h POSTER

New Role for Paleoclimatology: Routine Drought Monitoring

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The instrumental record of drought exists for 100 years or less for most of North America. This record is inadequate for assessing the rarity of major drought events of the 20th century, and may not represent long-term natural climate variability. Paleoclimatic records are critical for evaluating extreme drought events and drought variability in the 20th century in a broader temporal context. In the last decade, a number of studies have reconstructed drought from paleoclimatic records, primarily tree rings and lake sediments. One of these was the first gridded Palmer Drought Severity Index (PDSI) reconstruction from tree rings for the conterminous United States from AD 1700-1978 (Cook et al., 1999). It provided the first nationwide patterns of pre-instrumental drought and a dataset for all parts of the conterminous U.S. Further work has extended these reconstructions back in time and to most of North America. In 2002, NOAA Paleoclimatology became part of NOAA's National Climatic Data Center and collaborative efforts between the Climate Monitoring Branch and the NOAA Paleoclimatology began to incorporate pre-instrumental perspectives on drought into the monthly and annual State of the Climate (SoC) Reports. Each month authors of the SoC Report select regions to be highlighted in the United States Drought section. While previously limited to instrumental data, the report now often features paleoclimatic records, using either reconstructions from research targeting the area of impact, or using data from the gridded tree-ring reconstructed PDSI dataset. These paleoclimatic data provide a multi-century record from which users can better assess the severity of ongoing droughts relative to droughts of previous centuries. Additionally, SoC Report authors have included spatial reconstructions and indices of paleodrought at regional to national levels. The extensive U.S. droughts in 2002 made the addition of paleoclimatic data to the State of the Climate Reports especially valuable. However, paleoclimatic reconstructions are computed differently than their instrumental counterparts and almost never extend to the current year. Planned reconstructed drought records that better integrate with the instrumental record, and blended and "living" integrations of paleoclimatic and instrumental data will improve the way that these data products can be used together in the new North American Drought Monitor. References: Cook, E.R., Meko, D.M., Stahle, D.W., and Cleaveland, M.K. 1999. Drought reconstructions for the continental United States. Journal of Climate 12:1145-1162

URL: http://www.ncdc.noaa.gov/paleo/drought.html

PP52A-0944 1330h POSTER

Sahel Precipitation Variability and Global Sea Surface Temperature Forcing

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In the last 50 years or so, the Sahel region in sub-Saharan Africa has experienced two multi-decadal wet and dry periods separated by a relatively sharp transition. The onset of the dry episode in the Sahel is associated with the start of a significant warming trend in Southern Hemisphere sea surface temperatures (SST) that persisted well into the late 1990's. It has been stipulated, based on general circulation model (GCM) experiments, that the SST rise in the southern ocean basins is the predominant driver of rainfall patterns over the Sahel. Here we support this notion by comparing the observed rate of change in Southern Hemisphere SST with that of Sahel summertime rainfall. We examine the variations in each ocean basin separately and find that the drought pattern is most prominently associated with SST changes in the Indian Ocean, which display maximum warming rates simultaneously with the wet to dry shift in the Sahel. We provide further support to the role of the Indian Ocean using results from GCM integrations forced with observed Indian Ocean SST values and climatological values elsewhere, which effectively recreate the dry Sahel rainfall pattern. While the variations in equatorial Pacific SST associated with El Niño have been found to have an effect on Sahel rainfall during the summer months, their influence does not appear to be significantly connected with the prolonged drought episode. The dry period was accentuated by two severe droughts in the early 1970's and 1980s, which generated very different repercussions for the Sahelian people. The first drought resulted in widespread famine and death while the second more severe drought in 1983-84 generated very few casualties. The political and socioeconomic assessment of these episodes suggests that the extensive loss of life was due to inefficient transportation of supplies to the starving populations. International aid organizations initiated famine protection programs following the 1970's drought that helped to effectively counteract devastating famine in the 1980's.

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Extreme value for paleoclimatic data sets with an application in lichenometry

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To study marked peaks, abrupt changes and outliers in paleoclimatic data sets, it is important to develop statistical methodologies that are specially tailored to these extremes. This is especially fundamental because the definition of extreme events depends on the magnitude of any intrinsic thresholds and, consequently, the linearity of classical statistical tools based on averages is not anymore adapted. Although the statistics of extremes have played a central role in engineering practice for water resources management (floods) as well as in finance, extreme value theory has rarely been applied to the analysis of paleoclimatic data sets. The central theme of this talk is an application of the probabilistic theory of extreme values to the study of the largest lichen diameters from different moraines around the world. The advantage of this strategy over classical statistical lichenometric analyzes is that the uncertainties associated with studying the largest lichen diameters is fully taken into account through identification of the distribution of these largest diameters. In addition to providing a probabilistic framework, the flexibility of our statistical model allows to deal with situations where the chronological order of the moraines is either known or unknown. To validate our statistical methodology, simulated examples were analyzed and tested. Finally, the proposed techniques were applied to different sites from Bolivia and other regions.

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