risk (i.e., risk slowly and systematically changing with time) framework for flood frequency analysis as an alternative to the current practice of estimating the 100 year flood as a measure of static risk implied by a stationary process. Spatio-temporal variations in flood occurrence over a subset of the Western United States are first analyzed in the frequency domain. Then, we explore the implications of treating the flood process as stationary by computing the exceedances of a T-year flood estimated from a n-year record in the subsequent n years. This is done with one record of annual maximum floods from the West, and with a 1000 year series of annual maximum NINO3 values derived from a stationary climate run of the Cane-Zebiak model for the tropical Pacific. We compare the results from this analysis to a parallel analysis where the n years for estimating the T-year flood and the subsequent n years for computing the exceedances are drawn at random from the same record. The latter provides an analog for a climate-flood process that has no temporal structure. The probability distribution for the number of exceedances is seen to be much more heavy tailed for the structured case than for the random case, for all values of n explored, suggesting that the multi-scale variability in climate and floods will regularly translate into surprises for decisions on flood control where a static risk paradigm is used. This observation also has implications for the assessment of evidence of anthropogenic climate change in terms of climate extremes.

PP61B-09 1100h

Tropical Modulation of Low Frequency Precipitation Variability in the Western US During the Past 1200 Years

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We examine the relation between proxy reconstructions of Sacramento river flow and Southwestern US drought severity from tree-ring data, and tropical proxies for El Niño (Laguna Pallcacocha alluvial sediment record, Ecuador) and Pacific decadal variability (δ^{18}O from the Quelccaya ice cap, Peru). An important new result is a robust positive relation between El Niño activity and precipitation in Central and Northern California over the past 1200 years. This relationship is important from a paleo-climatic perspective because it establishes the multi-century stability of the response to El Niño forcing in this region, and because it provides support for the quality of both proxy records. A second important result is that the relation between proxy El Niño activity and indicators of precipitation over the Southwest US appears transitory rather than the positive relationship seen in the instrumental record. In contrast, we do find consistent agreement between proxy for Pacific decadal variability (Quelccaya δ^{18}O) and Southwestern US precipitation at multi-decadal time scales from various indices going back to 450 AD. This variability can also be found in records that have recently been used to document trans-hemispheric co-variability in decadal scale climate fluctuations in proxy records. Composites constructed using the proxy data indicate that the modulation of the El Niño- non-El Niño-related precipitation response over the Southwest demonstrated from the instrumental record has been a feature of the regional climate over the past 1000 years. We hypothesize on how this modulation is realized.

PP61B-10 1115h INVITED

The Little Ice Age in Mesoamerica

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The spatial and seasonal distribution of rainfall is highly variable across the Yucatan Peninsula today, and is affected by climate variability of both Pacific (e.g., ENSO) and Atlantic (e.g., NAO) origin. The northwest coast is driest and is marked by a steep precipitation gradient from a low of 450 mm/yr near Progreso (21.3°N), increasing to 1000 mm/yr at Merida (21.0°N), and 1150 mm/yr at Abala (20.7°N), representing almost a 3-fold increase over a distance of only 65 km with negligible topographic relief. The region is highly attractive for paleoclimate study because of the steep rainfall gradient that is this sensitive to past changes in the position of the ITCZ. Consequently, we studied a 5.1-m sediment core from Aguada Xcaamal (20.61°N, 89.72°W, max. depth = 12 m), a sinkhole lake located near the town of Abala, Mexico. Between 1400 and 1500 A.D., oxygen isotope ratios of the gastropod *Pyrgophorus coronatus* (spinose) increased by $3^{o}/_{oo}$ and the benthic foraminifer *Ammonia beccarii* became abundant in the sediment profile, providing strong evidence for a pronounced increase in evaporation/precipitation ratio (E/P) and the salinity of Aguada Xcaamal. This interpretation is supported by historical accounts of intense drought in the mid-1400s described in the Book of Chilam Balam of Mani (Gill, 2000), a town located only 45 km southeast of Aguada Xcaamal. Oxygen isotope values in sediment cores from Lake Chichancanab (19.9°N) and Lake Salpeten (17°N) to the south also show an increase in the mid 15th century, although the magnitude is less than that recorded in northwest Yucatan. Increased E/P on the Yucatan Peninsula in the 15th century coincided with the start of the Little Ice Age (LIA), and is synchronous with increased aridity inferred from trace metals (Fe and Ti) in the Cariaco Basin off Venezuela, and with expressions of the LIA in tropical and polar ice cores. Colder temperatures during the LIA are well known to have had a societal impact in Greenland and Europe, and decreased precipitation in Mesoamerica may have contributed to cultural change such as the collapse of the Mayapan hegemony in the mid 15th century (Gill, 2000).

Gill, R.B. (2000). Great Maya Droughts, University of New Mexico Press, Albuquerque.

PP61B-11 1130h

Cyclic Variability in Moisture Balance in Central Equatorial Africa During the Past 5000 Years

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Paleohydrologic variations in Africa are recorded by the chain of large East African rift lakes, whose climatic sensitivity and high sedimentation rates make them ideal for high-resolution reconstruction of past continental moisture balance. Among these lakes, Lake Edward, Uganda-Congo is ideally configured to record past variations in the African monsoon, situated on the equator at the eastern edge of the Congo basin. Analyses of the stable isotopic and chemical composition of authigenic calcite in three cores from Lake Edward covering the past 5,000 years show large, coherent shifts that reflect past variations in hydrologic balance. These chemical and isotopic stratigraphies exhibit both a long-term trend, suggesting increasingly arid conditions from 5 kyr BP culminating at 2 kyr BP, and high-amplitude sub-millennial variability. This short-term variability documents arid intervals centered at 4.6, 4.0, 3.4, 2.7, 2.0, 1.4, and 0.8 kyrs BP, the latter correlating with the Grand Solar Maximum and the European Medieval Warm Period.

The controls on past African moisture balance appear complex, potentially driven by solar forcing and/or related to Indian and Atlantic Ocean SSTs and high latitude events. The geochemical events in Lake Edward are not consistently correlated with solar forcing or with northern or subtropical Atlantic cold events. Spectral analysis of the Lake Edward data shows several weakly significant $<$ 200 year periodicities, as well as a highly significant period at 725 yrs. This 725-year period has been previously recognized in marine records from the Arabian and South China seas, suggesting teleconnections between East Africa rainfall and the Indian Ocean/Asian monsoon operate on long time-scales.

PP61B-12 1145h

Holocene South Asian Monsoon Climate Change Potential Mechanisms and Effects on Past Civilizations

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Planktonic oxygen isotope ratios from the laminated sediment core 63KA off the river Indus delta dated with 80 AMS radiocarbon ages reveal significant climate changes in the south Asian monsoon system throughout the Holocene. The most prominent event of the early-mid Holocene occurred after 8.4 ka BP and is within dating error of the GISP/GRIP event centered at 8.2 ka BP. The late Holocene is generally more variable, and shows non-periodic cycles in the multi-centennial frequency band. The largest change of the entire Holocene occurred at 4.2 ka BP and is concordant with the end of urban Harappan civilization in the Indus valley. Opposing isotopic trends across the northern Arabian Sea surface indicate a reduction in Indus river discharge at that time. Consequently, sustained drought may have initiated the archaeologically recorded interval of southeastward habitat tracking within the Harappan cultural domain. The hemispheric significance of the 4.2 ka BP event is evident from concordant climate change in the eastern Mediterranean and the Middle East. The late Holocene cycles in South Asia, which most likely represent drought cycles, vary between 250 and 800 years and are coherent with the evolution of cosmogenic radiocarbon production rates in the atmosphere. This suggests that solar variability is the fundamental cause behind late Holocene rainfall changes at least over south Asia.

PP62A MCC: Hall D Saturday 1330h

Past Changes of the Hydrological Cycle in the Tropics and Subtropics II Posters *(joint with A, H, OS, GC)*

Presiding: **A C Clement,** University of Miami**; L C Peterson,** University of Miami

P P

PP62A-0314 1330h POSTER

Sea Surface Temperature and Seawater Oxygen Isotope Variability Recorded in a Madagascar Coral Record

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Within KIHZ a coral from the lagoon of Ifaty off southwest Madagascar in the Mozambique Channel was examined. Based on temporal variability of skeletal oxygen isotopes annual mean sea surface temperatures are reconstructed for the period from 1658 to 1995. Sr/Ca ratios were measured for selected windows with monthly resolution (1973 to 1995, 1863 to 1910, 1784 to 1809, 1688 to 1710) to validate the SST reconstructions derived from oxygen isotopes. The coral proxy data were validated against gridded SST data sets.

The Sr/Ca-SST agree well with SST observations in the validation period (1863 to 1910), whereas the d18O derived SST show largest discrepencies during this time interval. By taking into account the SST values derived from coral Sr/Ca, we were able to reconstruct d18O seawater variability. This indicates that

d18O seawater variations contributed significantly to interannual and interdecadal variations in coral d18O. We propose that remote forcing by South Equatorial Current and/or Indonesian throughflow variability may contribute to observed d18O variability. The local surface-ocean evaporation-precipitation balance is also of importance. Our results indicate that coral d18O may be used to reconstruct temporal variations in the fresh water balance within the Indian Ocean on interannual to interdecadal time scales.

PP62A-0315 1330h POSTER

Decadal Scale Tropical Atlantic Sea Surface Temperature Indices as Recorded by a Modern Dominican Coral (1935-1996)

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In contrast to research in the tropical Pacific, there have been few definitive studies utilizing proxy records within Atlantic coral skeletons to provide information on the climate dynamics in this region. In order to study associations between salinity and temperature in the Subtropical North Atlantic, a core was retrieved from a colony of the coral species *Montastraea annularis* at El Pen located in the northwestern region of Parque Nacional del Este (PNE), Dominican Republic. Decadal oscillations in the δ^{18}O of the coral skeleton correlate with SST anomalies (SSTA) in the tropical North Atlantic for much of the period from 1935 to 1996. Cospectral analyses of coral δ^{18}O and documented tropical Atlantic SSTAs reveal a dominant frequency of 12-15 years. This decadal frequency is well documented in observed Atlantic SST data and models of tropical Atlantic climate. We do not believe that fluctuations in the δ^{18}O of this coral reflect local temperature or precipitation patterns. Instead we suggest that the δ^{18}O of the coral is related to Caribbean wide salinity anomalies, which are in turn related to tropical Atlantic SSTAs.

The correlation between coral δ^{18}O and tropical Atlantic SSTA may indicate that when a southward SSTA gradient is pronounced, tradewinds north of the ITCZ increase, enhancing evaporation in the North Atlantic Subtropical Gyre. The net increase in evaporation coupled with a strengthening of gyre circulation could result in a relative increase in the transport of more saline water into the Caribbean via the Mona Passage. When a northward SST gradient is present, precipitation associated with the northern extent of the ITCZ may decrease the mean salinity of the North Atlantic Subtropical Gyre and/or gyre circulation. A relative increase in the transport of less saline South Equatorial waters to the Caribbean could result. However, the correlation between coral δ^{18}O and tropical SST anomalies changes significantly between 1960 and 1970. This change coincides with an increase in the strength of the tropical Atlantic SSTA gradient and cooling in temperature as evidenced by a decrease in the Atlantic Multidecadal Oscillation. The change in correlation may support the idea of a transitory nature to the hypothesized Tropical Atlantic Dipole.

PP62A-0316 1330h POSTER

Decadal-Scale Tropical North Atlantic Climate Variability Recorded in Slow Growing Cape Verde Corals

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The decadal to century scale climate variability of the tropical North Atlantic has major implications for both neighboring coastal and inland areas. Changes in patterns of sea surface temperature (SST) and SST anomalies (SSTA) in the tropical North Atlantic are known to affect rainfall in Florida, South America, and sub-Saharan Africa, as well as the number of major hurricanes formed in the Atlantic. Because of the significance of these connections, it is important to further increase our predictive capacity for the recognition of trends and cycles in tropical North Atlantic SST and SSTA. Located at 15° N latitude off the west coast of sub-Saharan Africa, the Cape Verde Islands are an ideal geographic location to search for records of the Tropical North Atlantic Index (TNA). Such patterns are present in proxy indicators of climate (O, C, Sr/Ca and Mg/Ca) recorded in the skeletons of slow growing corals, such as *Siderastrea radians*, found in Cape Verde (growth rate = 1-2 mm/yr). These corals represent an archive for SST and SSTA records that exceed the instrumental period of the eastern tropical North Atlantic.

We cored corals from several different locations within the Cape Verde archipelago and analyzed them for stable isotopes (δ^{13}C and δ^{18}O) and minor elements (Sr, Mg, and Ba). The δ^{18}O signal present in these corals shows a distinct relationship to the TNA over the better part of the last 100 years. In addition, the δ^{18}O record in several of these corals also records the onset of the latest Sahel (11°-18° N in Africa) drought which began in 1970. The Sr/Ca and Mg/Ca records of these corals indicate a slight warming of the waters around Cape Verde during the last 100 years, as well as accurately recording the El Niño events of 1982-83 and 1997-98. The correlations present between the records in these corals and the known instrumental record for the eastern tropical North Atlantic suggests that the fluctuations recorded in the proxy indicators may be accurately used as a tool to study both the intensity and duration of SST and SSTA cycles as far back as the 1880s.

PP62A-0317 1330h POSTER

The Indo-Pacific Coral Diploastrea: A New Archive of Western Pacific Temperature and Precipitation

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The Western Pacific has been sparsely sampled with respect to coral paleoclimate records and not all those that exist greatly extend the historical climate record of this important region. The massive coral *Diploastrea*, a western and central Pacific coral genus, vertically accretes skeleton at only 3 to 5 mm per year. Growing at a rate less than half of the genus *Porites*, the most common coral used for paleoclimate studies, *Diploastrea* colonies preserve temporally longer geochemical proxy records of sea surface temperature (SST) and salinity than *Porites* colonies of the same length. Its long lifespan and fossil history give this genus great potential, however no assessment has been made of the paleoclimatic utility of *Diploastrea* skeletons.

We have retrieved coral cores from colonies of both *Diploastrea* and *Porites* from Savusavu Bay in Fiji (17.5° S, 178.5° E), a region likely sensitive to SST and precipitation changes due to activity of the South Pacific Convergence Zone (SPCZ) and the El Niño Southern Oscillation (ENSO). To calibrate *Diploastrea*, we have analyzed δ^{18}O and δ^{13}C on subannual samples from *Diploastrea* and *Porites* cores (period of overlap, 1941-1997). Sampling of *Diploastrea*'s exothecal material results in annual variations most similar to *Porites*. Variable seasonal growth rates coupled with a constant sampling interval have preferentially captured winter conditions in the geochemical composition of *Diploastrea*'s skeleton. These winter-biased δ^{18}O time series appear to track SPCZ activity as recorded by both pressure and precipitation-based indices, along with activity of the Southern Oscillation, as effectively as *Porites* for the period of comparison.

PP62A-0318 1330h POSTER

The Link Between continental weathering, strength of the African Monsoon and Middle Miocene Cooling: A Central Mediterranean Record.

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During the Plio-Pleistocene, the strength of the African monsoon is known to have played a major role in determining sedimentation pattern in the Mediterranean by triggering sapropels deposition through increased meteoric water input. Here we present a mixed siliciclastic-carbonate section outcropping on the Maltese Islands that suggests that sapropels deposits already existed in the Middle Miocene, and thus that an enhanced monsoonal climate was likely active at that time. Organic matter analysis at this location indeed reflects mixing of terrigenous and marine sources. Moreover, runoff proxies coupled with oxygen isotopes indicate that a direct link existed between strength of the Monsoon and Miocene global climate. Our astronomically calibrated age model shows that the African monsoon has probably initiated around 16.7 Ma and underwent a major strengthening around 13.8 Ma. We argue based on other studies results and on the teleconnection existing nowadays between the two monsoons that this is also true for the Asian monsoon.

PP62A-0319 1330h POSTER

Hydrological Changes in the Northern Red Sea Region: the Early Holocene Pluvial Period and Multi-Centennial Aridity Variations

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Proxy data for past surface ocean properties and continental rainfall based on two well-dated high resolution sediment cores from the northernmost part of the Gulf of Aqaba and off the southern tip of the Sinai Peninsula were used to infer hydrological changes at the southern margin of the Mediterranean climate zone during the Holocene. Past hydrographic conditions were deduced from stable oxygen isotope measurements on tests of shallow dwelling planktic foraminifera, pteropods, and benthic foraminifera, whereas sea surface temperatures were estimated with the alkenone paleothermometry method and subsequently used to extract the salinity signal from the δ^{18}O values. Vertical δ^{18}O gradients were calculated as the difference between the shallow dwelling planktic foraminifera *Globigerinoides ruber* (white), the deep planktonic mesopelagic pteropod *Limacina inflata*, and the benthic foraminifera *Cibicidoides mabahethi* δ^{18}O records. Between 9.8 and 6.25 thousand years ago up to 3.5 reduced surface water salinities and increased vertical δ^{18}O gradients suggest a distinct freshening of the surface ocean. Terrigenous sediment composition and its supply rate to the Gulf of Aqaba changed dramatically at the end of the early to mid Holocene low-salinity period. End member modeling of the grain-size distributions of the terrigenous sediment fraction suggests a shift in the dominant mode of sediment transport pointing to a significant decrease in regional rainfall. The northern Red Sea humid interval is best explained by enhancement and southward extension of rainfall from Mediterranean sources most likely involving regional monsoon-type circulation patterns induced by increased land-sea temperature contrasts. We conclude that Afro-SW-Asian monsoonal rains did not cross the subtropical desert zone during the early to mid Holocene. Additionally, several multi-centennial to millennial-scale variations can be observed in both the marine and continental proxies. A general correspondence of our aridity record with the North Atlantic proxy record of changes in drift ice suggest a broad teleconnective response to Holocene variations in solar output linking colder ice-bearing surface waters in high northern North Atlantic latitudes with less arid conditions in the northernmost Red Sea area and probably involving long-term changes in the AO/NAO anomaly pattern throughout the Holocene.

PP62A-0320 1330h POSTER

The Evolution of a Freshwater Wetland in a Semi-arid Environment, Loboi Swamp, Kenya

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Loboi Swamp is situated near the equator on the western fault-bounded margin of an asymmetric half-graben within the East African Rift valley. The freshwater wetland is 3km2 and developed during mid to late Holocene on the low relief floodplain of the axial Loboi River. The swamp is groundwater-fed by several springs and seeps associated with the border fault system. Spring waters are 35°C, with pH 6.4-6.9 and the water compositions suggest that the sources are shallow, and dominated by meteoric water with little contributed by deep re-circulating fluids. The climate is semi-arid. P is 700 mm/yr on the valley bottom and 1200mm/yr in the adjacent highlands; ET is estimated to be 2500 mm/yr. Variation in precipitation occurs on a range of time scales: semi-annual monsoonal rains in Nov. and April; El Nino and La Nina periods every 5-7 years; and long term variations in climate are also likely, such as, orbitally-forced Precession cycles (20ka).

The modern swamp is dominated by Typha domingensis Pers. (80%) and Cyperus papyrus L. (20%), a crocodile habitat. The stratigraphy revealed in a soil pit and 8 piston cores (1.5-4 m long) records the formation, evolution and maybe the beginning of the demise of the wetland. Basal sediments are floodplain (sandy silts) that fine upward to f. silt and clay and are capped with organic-rich sediment (peat). Subparallel siderite concretion horizons in the silts indicate that Fe-reducing conditions developed as the basal sediments were flooded by the developing wetland. The peat is thickest (1.5 m) in the spring-proximal area near the fault and thins to 0.30m in the spring-distal areas. The appearance and expansion of peat indicates moister climate, however preliminary pollen analyses reveals that Cyperaceae and Tpyha are less abundant now than earlier suggesting a change from moister to drier conditions after the development of the swamp. Surface and porewater compositions in the swamp are modified by processes of evaporation and decay of organic matter.

Soils and paleosols developed on the periphery of the wetland reveal evidence for dramatic fluctuations in hydrologic budget, as indicated by formation of siderite and redoximorphic features during wetter phases, and vertic (shrink-swell) and clay illuviation features during drier phases. The combined records of sedimentology, soils, and pollen suggests a gradual change (over few thousands years) to wetter conditions and then to generally drier conditions with superimposed shorter term wet-dry cycles (hundreds of years to decades?).

PP62A-0321 1330h POSTER

Lowstands in Lake Bosumtwi, Ghana Suggest Episodes of Late-Quaternary Lowland Tropical Aridity

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We present findings from the first seismic-reflection survey from Lake Bosumtwi, Ghana, correlated to lithologic and geochemical results from ^{14}C-dated sediment piston cores. We reconstructed the basins late-Quaternary lake level history as an indicator of regional aridity. Lake Bosumtwi, a hydrologically closed lake located at the atmospheric equator (Intropical Convergence Zone) and just south of the Sahel region, is ideally situated to preserve temporal variations in the area's hydrologic budget. An exposure surface from a sediment core and four seismic sequence boundaries from the high-resolution, single-channel seismic data, are interpreted as erosional surfaces formed during low lake levels. The most recent erosional surface occurs ∼31 m below present lake level (bpll) and up to 1.7 m below the present sediment-water interface. This unconformity is believed to be co-eval with the basinwide late-Holocene dry period between 0.5-1 cal kyr BP (calendar years before present), now well-dated in sediment cores. Another exposure surface observed in a sediment core is evidenced by an abrupt contact separating low density, wet, clay rich sediments from underlying high density, compact, silt-rich and rootlet-rich sediments, and is inferred to have developed ∼17.5 cal kyr BP when the lake was ∼60 m bpll. Three older erosional surfaces occur at depths of ∼92, 102, and 107 m bpll, suggesting lowstands in Lake Bosumtwi during the late-Pleistocene. By extrapolation of sedimentation rates from the upper ∼10.5 m of sediment, we estimate the ages of these older lowstands as ∼69, 85, and 107 cal kyr BP. The lowstands of Lake Bosumtwi evidenced from the seismic and sediment core data are interpreted as a response to increased aridity in this part of the equatorial tropics.

PP62A-0322 1330h POSTER

The Varved Sediments of Lake Bosumtwi, Ghana and Implications for a new Chronology of West African Hydrologic Change During the Late Quaternary

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Lake Bosumtwi is a small (8-km diameter), deep (78-m) crater lake in the lowland forest of southern Ghana (West Africa) that offers tremendous potential for high-resolution environmental reconstruction. Lying in the path of the seasonal Intertropical Convergence Zone (ITCZ) monsoonal precipitation procession, as well as the dry Harmattan winds of the Sahel in winter, this lake is uniquely located to provide potential proxy records of these dominate climatic phenomena effecting West Africa's hydrologic cycle. The lake exhibits excellent sediment preservation, with finely laminated sediments through most of the ca. 24,000 years of core material recovered thus far. We present a detailed chronological analysis of the uppermost 1.1 meters of laminated sediment, obtained via a recently collected suite of freeze- and piston-cores. Utilizing digital images and petrographic thin-section transects of six freeze-cores and two piston cores, we identified 400 diagnostic marker laminations common among the cores, thus enabling cross correlation of the cores to a sub-centimeter scale. The marker laminations also serve as anchor points for counts of organic-rich fine-laminations that were hypothesized to be annual. Excellent agreement between our lamination counts and independent radiometric sediment age models (lead-210 and bomb radiocarbon) verify that these counted laminations are in fact annual (i.e. varves). Thus, we are able to present an annual chronology for the last 800 years of sedimentation (prior to 2000 AD) ∼4%. Though anthroprogenic changes have probably effected the local environment within the last 100 years, as we interpret anomalous increases in %organic carbon, %inorganic carbon and %nitrogen to indicate, the varve appearance does not seem to change across the 1.1 m section analyzed. Pre-nuclear weapon testing radiocarbon values, derived from bulk organic carbon, were examined in relation to the varve and lead-210 age-models to assess radiocarbon age offset due to reservoir effects and the redeposition of old-carbon; the data suggest that anomalously old radiocarbon ages ranging from ∼430 to 3000 years are possible. The size of the radiocarbon bias may vary with lake status, indicating the role of old-carbon redeposition from ancient lake sediments currently at shallow depths or above current lake level in the crater catchment. Our study shows that 1) varves have excellent potential for creating a high-resolution chronology for Lake Bosumtwi, and 2) caution must be taken in using radiocarbon results to date the sediments of Lake Bosumtwi

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Asynchronous Little Ice Age Megadroughts in Sub-Saharan Africa

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Lake Bosumtwi is a small (8 km-dia.), deep (78 m), hydrologically-closed lake located in the lowland forest zone of southern Ghana, West Africa. The steep-walled meteorite crater basin (10.5 km-dia.) is particularly sensitive to subtle changes in the regional precipitation-evaporation balance, and thus has long been cited as a benchmark paleoenvironmental site for West Africa. In an effort to enhance the value of the Bosumtwi sediments in reconstructing decade to century-scale monsoon variability, we collected a new suite of freeze-cores, and subsequently determined (e.g., with two independent radiometric systems) that the finely laminated sediments represented annual varves (Wheeler et al., AGU Fall Meeting 2002). In light of previous studies, we hypothesized that the ratio of carbon to nitrogen in the lake sediments provides a proxy for changing lake area, and hence regional hydrologic balance and monsoon strength. We confirmed the reliability of this proxy by comparing the sediment based ratio of carbon to nitrogen (C:N) against the age of well-dated dead trees submerged in water depths of 10 to 20m, and then created the first near-annually dated record of West African rainfall extending back eight centuries. The 20th century has been the wettest of the last eight centuries, with the 19th century close behind. Prior to ca. 1800, the Lake Bosumtwi region was generally characterized by drought, with the periods prior to 1300, and 1640 to 1720 AD the driest. This contrasts with comparable records from East Africa, and indicates that much of the Little Ice Age, including some hypothesized periods of reduced solar output, did not result in synchronous enhanced precipitation across North Africa. Instead, it appears that the solar Maunder Minimum resulted in a megadrought in subtropical West Africa coincident with increased rainfall in the Sahel. Thus, the out-of-phase relationship that characterizes interannual variability may extend to longer time scales of variation as well. In addition, anomalously strong Atlantic trade winds and cool SSTs appear to have been associated with the 80-year 17th to 18th century West Africa megadrought.

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Relations between the Hydrologic Cycle and Removal of Stable Isotopes of Water Vapor by Tropical Precipitation Systems

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The mechanisms by which precipitation scavenges the heavy isotopes of water (HDO and $H_2{}^{18}O$) from the ambient vapor are elucidated. It is shown that extensive, long-lived precipitation systems with organized convergent flow in the atmospheric boundary layer reduce stable isotope concentrations markedly without any concomitant reduction in specific humidity. The stable isotope concentrations of water vapor therefore serve as markers of the vigor of the hydrologic cycle in the tropics that must be taken into account in any interpretation of past temperature changes. Trajectory analysis is applied to data collected from field experiments in order to provide a measure that relates activity of tropical rain systems to the reduction of stable isotope concentrations in water vapor.

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Sedimentary Sulfur Variability in Lake Sediments of the Bogota Basin as Evidence for Orbital Forcing of Rainfall Patterns in the Tropical Andes

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The Funza record of the Bogota Basin in Colombia comprises a thick (150 m) lacustrine sequence encompassing the last million years. This unique record, therefore, offers a rare opportunity to assess high-resolution climatic changes in the tropical Andes during the late Pleistocene. Pollen data from the Funza record have revealed altitudinal fluctuations of the upper Andean tree-line, interpreted to result from temperature fluctuations. Moisture balance reconstructions based on pollen data have been inconclusive for the Bogota Basin, as Andean vegetation appears to be more sensitive to temperature changes. Here, we measured the abundance of sedimentary sulfur species in Funza sediments as a potential proxy for rainfall because sulfur speciation in lake sediments has been observed to be controlled by rainfall-induced fluxes of reactive iron from the watershed. Total sulfur abundances in the studied Funza sediments were consistently low, ranging from 0.1 to 0.8 wt. percent. However, monosulfides/total sulfur ratios in Funza sediments exhibit a strongly cyclic pattern, ranging from 0.2 to 0.9. Chemical analyses indicate that, in addition to iron monosulfides, the total sedimentary sulfur pool includes organo-sulfur compounds. We explain the partitioning of sedimentary sulfur between monosulfides and organic sulfur in terms of iron availability in the system. We suggest that monosulfide-dominated intervals are related to high lake-levels and result from the reaction of reduced sulfur with reactive iron. In contrast, predominance of organo-sulfur compounds occurs when reduced sulfur reacts with organic matter in the absence of iron in the system. Because rainfall strongly controls the delivery of iron to tropical lakes, we thus propose sulfur ratios as a proxy for rainfall in the Bogota Basin. Using this proxy, we found that the driest periods (monosulfide/total sulfur minima) in the basin were typically associated with glacial maxima. Spectral analysis of the sulfur species in the Funza record reveals a cyclic distribution with periodicities closely associated with Earth's orbital variations. Modern rainfall patterns in northern South America are dependent on the position of the Inter-Tropical Convergence Zone (ITCZ). The spectral results, therefore, point to orbitally forced shifts of the ITCZ in tropical South America during the late Pleistocene.

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Reconstruction of River Outflow, Vegetation Dymanics and Fire History of the Amazon Basin for the Last 40ka.

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Little is known of the glacial moisture history of the Amazon Basin, and debate exists as to whether it was in fact humid or arid within this time period; but here we present unequivocal evidence to suggest widespread aridity within the Amazon Basin during the Last Glacial Maximum (LGM). We have used $\Delta\delta^{18}O$ to serve as a proxy for contemporaneous moisture levels, and have used it to make the first attempts to actually quantify the Amazon River discharge back to 40 ka. Our initial calculations reveal it to have been around 50% of the modern outflow during the Younger Dryas, and reduced even further during the LGM.

Other palaeoclimate proxies have allowed us to examine the internal dynamics of the Amazon Basin. Biomarker analyses (isotopic and abundance, respectively) have enabled us to examine the rainforest structure over the last 40ka, particularly relative changes in $C_3 : C_4$ vegetation (trees: savannah, thus relative rainforest extent), and have also provided a unique opportunity to reconstruct a history of fire frequency within the Amazon Basin. ICP-ms analyses have allowed us to track variations in the source and quantity of the Amazon River sediment discharge. Data reveals both centennial and millennial-scale variability, which are most likely climate-driven.

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Variation in the Strength of the Central American Monsoon During the Holocene From Speleothem Proxy

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We are investigating the Holocene history of the Intertropical Convergence Zone (ITCZ) and the Central American Monsoon system based on stable isotopic time series of Panamanian and Costa Rican speleothems. Stalagmite chronologies are constrained by U-series disequilibrium dates and indicate stalagmite growth spanning several intervals during the past 8.6 kyr BP. Interpretation of stalagmite $\delta^{18}O$ profiles is aided by study of the modern controls affecting the spatial and temporal variability of stable isotope values of tropical surface water and precipitation. We collected ~230 surface water samples from the Darien Gap to Lake Nicaragua and the Caribbean Sea to the Pacific Ocean to constrain spatial variation of $\delta^{18}O$ along climatic gradients. Analysis of temporal variability in stable isotope values in precipitation from stations in Panama and Costa Rica, collected by the Global Network for Isotopes in Precipitation, indicates that $\delta^{18}O$ values display an inverse relationship to rainfall amount. In the stalagmite record, the early Holocene is characterized by highest $\delta^{18}O$ values, interpreted as drier conditions related to a weaker monsoon system compared to the mid-Holocene. A stalagmite from the Caribbean Slope of Panama indicates a trend to higher $\delta^{18}O$ values to the present, consistent with decreasing rainfall observed in meteorological records over the last century. Cyclical $\delta^{18}O$ variability on decadal to centennial time scales indicates changes in the strength of the Central American Monsoon.

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Evaluating Multi-Proxy Records of Paleocyclones in Florida Coastal Sediments

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Cyclones are one of the most effective geomorphic agents, causing rapid changes in patterns of deposition and erosion through intense wind and wave energy and coastal flooding. Since historical records in the Atlantic Basin only extend back 370 years, a longer record is needed of past cyclone occurrences in order to better evaluate recurrence intervals (e.g. paleoclimate) and associated geomorphic change. Sand beds in coastal ponds and marshes have frequently been associated with cyclone overwash deposition, although other transport agents can result in similar type deposits. The purpose of this study was to evaluate a number of coastal pond sedimentary proxy records for their utility as paleocyclone indicators. Two sets of piston cores were taken 30 m from the beach in coastal ponds on St. Vincent Island, Florida, a relatively undisturbed island on the panhandle that has been frequently disturbed by hurricane activity. A variety of different proxy records (grain size, magnetic susceptibility, gamma bulk density, sediment reflectance, micropaleontology, salinity, %C and N) were analyzed in these cores to detect two major hurricanes known to have severely impacted the island in 1894 and 1985, as well as additional minor hurricanes. Measurements of bulk density and magnetic susceptibility were obtained with a multi-sensor core logger, then cores were split and examined visually and x-radiographically for lithology. The cores were sampled at 1 cm intervals for measurements of radioisotopes (Pb-210, Ra-226, and Cs-137) and the aforementioned proxy records. Geochronological results indicate an average sedimentation rate of 1.5-2 mm/yr. Sorting and micropaleontological (foram abundance) data display some evidence of hurricane deposits corresponding to 1894 and 1985. However, none of the proxy records show clear evidence of all known hurricanes. Thus, these commonly measured proxies are unsuitable for paleocyclone studies in coastal ponds in Florida. Possible reasons for this include: (1) the vegetation separating the ponds from the beach may prevent much of the overwash from reaching the ponds and (2) bioturbation within the ponds would cause a mixing of the sediments that would destroy storm-produced bedding.

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Glacial-Interglacial Sea Surface Temperatures in the Equatorial Western Pacific Using a Multiproxy Strategy

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The main source of water vapor in the atmosphere comes from the Western Pacific Warm Pool (WPWP) where deep atmospheric convection is linked with the warm SSTs (>28°C). The stability of the SSTs in this area during the last climatic cycles is critical for the global hydrological cycle. We investigated past changes in SSTs of the WPWP during the last 180,000 years, applying three independent methods: alkenones, Mg/Ca in the planktonic foraminifera *G.ruber* and transfer functions based on planktonic foraminifera in core MD97-2138, located north of Papua New Guinea. For the latter, to circumvent dissolution and biases linked to hydrological structure we developed a new regional transfer function (TROP-2), which we calibrated with intertropical core-tops excluding the Eastern Pacific area where anomalous high abundances of *N.dutertrei* may result more from the High Nitrate Low Chlorophyll ecosystem than from temperature or thermocline depth gradients. Using this new transfer function, the core-top-Last Glacial Maximum SST difference is about 0.1-1.3°C, roughly consistent with CLIMAP estimates. However, the total Late Glacial-to-Holocene SST range here, based on both proxies, is substantially greater, about 2.2°C. Within the past ≈30 ka, the coldest conditions occurred near 18 cal. ka BP, younger from the L.G.M. s.s, and the warmest interval occurred between 5-9 ka, in the early Holocene. The stage 6 - stage 5 difference is about 2°C using TROP-2 and only 0.9°C using the alkenones method, and overall the time series from the two different proxies are different. Nevertheless, we conclude that in the WPWP, a strategy of calibrating regional, ecosystem-relevant transfer functions yields better estimates of SST change, and based on this proxy, peak warm and cold conditions here were not coincident with modern and LGM time intervals. The result of ongoing Mg/Ca analyses will be compared to alkenones and planktonic foraminifera transfer function. The total range of SST variability in the region using these two latter proxies is 2-3°C in late Pleistocene time. This range indicates that the deep atmospheric convection over the WPWP was a pervasive feature of the climatic system.

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Reconstruction of Eastern and Western Tropical Pacific Sea Surface Temperatures and Oxygen Isotopic Composition of Surface Seawater, 5 Ma to Present

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Tropical Pacific sea surface temperatures (SST) exert a fundamental influence on both the pattern and absolute magnitude of atmospheric water vapor concentration, cloud cover, net radiation budget, and thus global climate. The history of tropical SST and of the Tropical Pacific air-sea interaction that leads to a large zonal SST gradient on the equator is critical to a complete understanding of tropical atmosphere and global climate change on time scales from years to millions of years.

We present paired measurements of magnesium/calcium (Mg/Ca) and $\delta^{18}O$ on the planktonic foraminifera *Globogerinoides sacculifer* (w/o sac, 355-425μm) at one site in the eastern (ODP site 847, 0°N, 95°W, 3346m water depth) and one in the western (ODP site 806, 0°N, 160°E, 2520m water depth) Tropical Pacific. Both records extend from 5.3 Ma to present with a sampling resolution of ∼10 kyr. We utilize these records to reconstruct SST and the oxygen isotopic composition of surface seawater at both sites, as well as the zonal gradients of these properties in the Tropical Pacific Ocean from the Early Pliocene to the Late Pleistocene.

Temperature estimates for ODP site 847 indicate that prior to ∼2 Ma, mean SST was ∼ 25±1.4°C, decreasing after 2 Ma to ∼23±1.4°C. This change is coincident with the development of a foraminiferal oxygen isotope gradient between ODP sites 847 and 806, and represents a critical time in the development of the modern Tropical Pacific SST gradient, and possibly the air-sea interactions that sustain strong Walker circulation. No SST change at ODP site 847 coincident with either the hypothesized closing of the Panamanian Isthmus at 4.2 Ma, with the development of a strong $\delta^{18}O$ contrast between surface and deep dwelling planktonic foraminifera between 5 and 4 Ma, nor with the initiation of northern hemisphere glaciation at 3.2 Ma.

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A Multi-proxy Approach to Distinguish Between Changes in SST and Meltwater Input in the Gulf of Mexico Back to MIS 3.

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The Gulf of Mexico (GOM) is part of the Western Hemisphere Warm Pool providing a source of heat and moisture to the North American continent and Northern high latitudes. Paleoclimatic records from the GOM can test the hypothesis that the tropical climate system is an important driver of past global climate change. In July 2002, core MD02-2551 was taken by the French research vessel *Marion Dufresne* at 26°56.78 N91°21.75 W and recovered 31.79 m of sediment from Orca Basin situated in the northern GOM 290 km south of the present Louisiana coast. The basin is advantageous for high-resolution paleoclimatology because of a brine layer overlying the sediment that preserves sedimentary laminations and high sedimentation rates estimated at greater than 50 cm/1000 yr.

A multi-proxy approach using Mg/Ca and δ18O from foraminiferal calcite will isolate past sea surface temperature (SST) and δ18O of sea water (controlled by salinity, and ice volume). Separation of these parameters will help establish the relationship between changing GOM SSTs and meltwater input from the Laurentide Ice Sheet. The chronology of the core is being established using AMS C14 dating. Both white and pink species of the planktonic foraminifera *Globigerinoides ruber* were analyzed for δ18O and will be analyzed for Mg/Ca. Coarse resolution data from white *G. ruber* show a mean value of about -1.5 per mil during the Holocene (low variability of <0.5 per mil) and a mean value of about 0.0 per mil at the Last Glacial Maximum (low variability of <0.5 per mil). Marine Isotope Stage Three (MIS 3) indicates a mean value of about -0.75 per mil (high variability of >0.5 per mil). Sea surface temperature and sea surface salinity have distinctly higher variability during MIS 3 in comparison to the Holocene. Foraminiferal Mg data will add an additional constraint for SST. Phasing between GOM SSTs and high latitude temperatures will help assess the role of the tropical climate system on global climate change.

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Hydrological and Temperature Changes in the Western Caribbean During the Last Glacial Cycle

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Today, the Caribbean has a profound effect on the sea surface temperature (SST) and sea surface salinity (SSS) of waters that eventually flow into the Florida Current and become part of the Atlantics northward-flowing component of the global-conveyor belt. Thus, changes in Caribbean SST and SSS over the last glacial cycle may be intimately linked to changes in the magnitude of oceanic heat and salt transported to the North Atlantic.

Stable oxygen isotope ($\delta^{18}O$) and Mg/Ca ratios from planktonic foraminifera *Globigerinoides ruber s.s.* (white variety) were measured at ∼1.25 kyr. resolution through the last glacial cycle from core ODP 999A (sed. rate 4-10 cm/kyr), Colombian Basin, western Caribbean. Calculated Mg/Ca-SSTs, based on a published core top calibration, were combined with *G. ruber* $\delta^{18}O$ to estimate past seawater $\delta^{18}O_{water}$ ($\delta^{18}O_w$) using a laboratory calibrated $\delta^{18}O$-temperature relationship.

Late Holocene Mg/Ca (4.09 mmol/mol) yield SSTs in agreement with the average modern SST of 28.5°C. Glacial Mg/Ca (3.41 mmol/mol) suggest the western Caribbean was 2.5°C cooler during the last glacial maximum (LGM). Deconvolved $\delta^{18}O_w$ values for the Late Holocene of the Colombian Basin average $0.9^o/_{oo}$, in agreement with modern $\delta^{18}O_w$ values. The structure of the $\delta^{18}O_w$ reconstruction reflects regional hydrographic changes during the last glacial cycle, superimposed on the longer-term variations in continental ice volume. In order to remove the ice volume effect, a recently published $\delta^{18}O_w$ reconstruction from eastern equatorial Pacific core TR163-19, thought to contain a continuous record of ice volume and sea level changes (Lea et al., 2002), was subtracted from that in ODP 999A. The resulting excess $\delta^{18}O_w$ record ($\Delta\delta^{18}O_w$) for Caribbean surface waters reflects regional salinity variations. These data suggest that $\Delta\delta^{18}O_w$ was enriched by ∼0.5 to $0.6^o/_{oo}$ beyond the contribution from ice volume during the LGM, MIS 4, and MIS 6. In contrast, MIS 3 and 5 show $\delta^{18}O_w$ values about equal to modern values. If the slope of the modern Caribbean $\Delta\delta^{18}O_w$:surface salinity relationship ($\delta^{18}O_w$ = (0.215)SSS 6.946) was valid throughout the last glacial cycle, these elevated $\delta^{18}O_w$ values would imply an increase in Colombian Basin LGM salinity of $\sim 2.8^o/_{oo}$, beyond the influence of ice-volume.

A comparison of a previously published benthic $\delta^{13}C$ proxy used to gauge variability in the formation of North Atlantic Deep Water (NADW) with $\Delta\delta^{18}O_w$ from the Caribbean indicate that as NADW production slows, the SSS in the Caribbean increases. This correlation suggests that elevated Caribbean salinities are associated with phases of NADW weakening and North Atlantic thermohaline circulation shut down.

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Gulf of Mexico Sea-Surface Temperatures and Laurentide Meltwater Input During MIS 3: Implications for High/Low Latitude Linkages

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A new sediment core from the Orca Basin, Gulf of Mexico, will be helpful in determining the role of low latitude ocean dynamics in rapid climate change. The 31.79-m core (MD02-2551; 26°56.78'N, 91°21.75'W), obtained in July 2002 aboard the R/V *Marion Dufrense* will provide, for the first time, an opportunity to study Gulf of Mexico sea-surface temperature (SST) and sea-surface salinity (SSS), as well as meltwater input from the Laurentide Ice Sheet (LIS) during the Dansgaard-Oeschger (D-O) cycles found in Marine Isotope Stage (MIS) 3, 24-57 ka. The anoxic Orca Basin, which sits 290 km south of the Mississippi Delta, is filled with a hypersaline brine resulting in undisturbed laminations and excellent preservation of planktonic foraminifera. A coarse resolution isotope stratigraphy of the core using *Globigerinoides ruber* (pink and white variety) with a size fraction from 250-355 microns and faunal abundances suggests the oldest sediments are from MIS 3, resulting in an average sedimentation rate of >50 cm/1000 years. A distinct negative isotope anomaly, reaching $\delta^{18}O$ -4 $^o/_{oo}$ based on pink *G. ruber*, occurs at 2625 cm, which is best explained by increased meltwater input from the LIS. More detailed work on the core, including AMS ^{14}C age control, will demonstrate how SST and meltwater input relate to D-O events. Multi-proxy data, including $\delta^{18}O$, Mg/Ca and Uk'37, make it possible to deconvolve SST and SSS. Understanding the relationship between subtropical SST, Greenland air temperatures and high latitude SST, in addition to LIS meltwater input, will test the hypothesis that subtropical SST changes lead high-latitude climate change.

PP62A-0334 1330h POSTER

Estimates of Late Pleistocene Runoff in Estancia Drainage Basin, Central New Mexico: Climate Assumptions vs. Model Results

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The climatic conditions leading to highstands of "pluvial" Lake Estancia in central New Mexico have been a matter of considerable debate, resulting in a wide range of estimates for Pleistocene precipitation and temperature in the southwestern United States. Using a simple hydrologic balance approach, Leopold (1951) calculated that precipitation was 50% greater than modern based on the assumption that summer temperatures were 9 °C colder while winter temperatures were unchanged. In contrast, Galloway (1970) called on temperature decreases of 10-11 °C throughout the year and a reduction in mean annual precipitation of 14% to raise Lake Estancia to its highstand. In still another study, Brakenridge suggested that highstands could be achieved through no change in precipitation if monthly temperatures were reduced by 7-8 °C.

Experiments with 3 physically-based, continuous-time models to simulate surface runoff (USDA Soil and Water Assessment Tool), groundwater flow (MODFLOW with LAK2 package), and lake evaporation (lake energy balance model of Hostetler and Bartlein, 1990) indicate that none of these proposed full glacial climate scenarios could have produced a highstand lake. In particular, previous workers appear to have overestimated the reduction in evaporation rates associated with their proposed temperature changes, suggesting that using empirical relationships between modern air temperature and evaporation to predict late Pleistocene evaporation is problematic. Furthermore, model-determined reductions in lake evaporation are insufficient to allow for lake expansion as suggested by Galloway and Brakenridge. Even under Leopold's assumption that precipitation increased by 50%, modeled runoff appears to be insufficient to raise Lake Estancia more than a few meters above the lake floor.

PP62A-0335 1330h POSTER

Record of Abrupt Deglaciation in the Arid Southwest United States From Speleothem Deposits

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Climate records developed from proxies available in the southwest to date include packrat middens, which provide only snapshots of climate, and tree-ring reconstructions, which are well dated and annually resolved but usually extend over fewer than 2000 years. Lacking are continuous lengthy records of climate that extend through the late glacial into the Holocene. Improved understanding of how the climate of the arid southwest responded to the changing forcing mechanisms over this interval is relevant to envisioning how the region will respond to future changes in natural and anthropogenic forcing. Speleothems commonly preserve millennia-long, continuous, high resolution records of temperature, precipitation, and/or vegetation history, and can be precisely dated using U-series methods. We analyzed a stalagmite from Cave of the Bells (elevation 1700 m) located on the eastern side of the Santa Rita Mountains southeast of Tucson, Arizona. First round U-Th dates indicate the sample spans the late Pleistocene through early Holocene, 55,000 to 9,500 years BP. High resolution (∼50 year) oxygen and carbon isotopes indicate an abrupt deglacial shift that transpires in less than 100 years from cooler and/or moister glacial conditions. Low-resolution U/Th dates place this transition around 10,500 years BP; higher resolution dates are needed to identify the precise timing of this event, however. The magnitude of the $\delta^{18}O$ shift is about +2.5 per mil (Holocene - Glacial) qualitatively consistent with other reconstructions from the region, which indicate more effective moisture and lower temperatures in the southwest during the late glacial. However, our record implies less change than is inferred from some packrat midden vegetation data. Our record may also be influenced by changes in precipitation seasonality inferred from other sources. Our results are consistent with the temperature and precipitation changes reconstructed by GCM simulations of the glacial-interglacial contrast in this region. Both the oxygen and carbon isotopic data also indicate significant sub millennial variations before and after the deglacial shift.

PP62A-0336 1330h POSTER

A Comparison of "Ice-House" (Modern) and "Hot-House" (Maastrichtian) Drainage Systems: the Implications of Large-Scale Changes in the Surface Hydrological Scheme

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A GIS analysis of modern and Maastrichtian (Late Cretaceous) drainage systems has been made in order to investigate the potential differences between the surface hydrology of "ice-house" and "hot-house" worlds and how this might be reflected in the geological record. Because of the importance of CO_2 concentrations for generating "hot-house" climates this study also has implications for potential future changes in the climate system.

For the modern system we have utilized global maps of observed river systems, the Hydro1K digital dataset, observations of freshwater and sediment fluxes from recording stations, and modern day climate models and observations. For the Maastrichtian we have compiled a detailed global paleogeographic map and geological database (based on earlier work by the Paleogeographic Atlas Project, University of Chicago) that has been used to generate a paleo-DEM using the suite of hydrological tools in ArcGIS, complete with reconstructed river systems and drainage basins. This forms the primary boundary condition for a coupled ocean-atmosphere experiment using the HadCM3 model, with atmospheric CO_2 set at 4 x pre-industrial levels.

The results indicate a Maastrichtian world dominated by high sea surface temperatures (as high as 30-35 C in the tropics), and a consequently greatly enhanced hydrological cycle when compared with the Present. Globally, modeled Maastrichtian precipitation and evaporation are 1.5x that for the Present, with a 2.5x increase in total runoff. These changes are not evenly distributed, either spatially or seasonally, and therefore a detailed consideration of the paleogeography and paleo-drainage is essential, as these changes have a major influence on the distribution of vegetation and freshwater and sediment fluxes.

For example, the Maastrichtian Tethyan monsoon, though less intense than noted for other modeled Mesozoic intervals, nonetheless dominates the seasonal distribution of precipitation and runoff over Saharan and northeastern Africa. Seasonally high, modeled freshwater fluxes from the Hoggar Massif (northern hemisphere Summer and Fall) drain south into the Iullemmeden Basin, where they augment persistent runoff from the southern Saharan areas including the proto-Niger drainage. The modeled vegetation and weathering regime of the surrounding hinterland is dominated by everwet tropical forests and intensive chemical weathering, consistent with interpretations from sedimentological and palaeontological observations: the dominance of carbonaceous-rich silts and clays, lack of evaporite minerals and lack of coarse immature clastics.

We speculate that changes in the distribution of the seasonal wet-everwet climate regimes due to Milankovitch forcing may account for the cyclicity observed in the Maastrichtian stratigraphy of this region. Along the North African margin the picture is very different with low rates of runoff, high evaporation rates and aridity. This aridity is enhanced locally by the atmospheric consequences of offshore oceanic upwelling.

The large differences in the surface hydrology of the Earth between the Maastrichtian "hot-house" and Present-day "ice-house" worlds clearly indicates that we must be prepared to model regimes that may in some areas be very different from the present day. Variations in the distribution and intensity of rainfall may trigger rapid changes in vegetation cover, groundwater levels and activity of soil infauna such as termites, which in turn would greatly affect terrestrial sediment flux and carbon flux responses.

PP62A-0337 1330h POSTER

Did Latent Heat Transport Increase in the "Hothouse" Climate of the Eocene?

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The past "hothouse" climate of the Eocene (50 Mya) is one of the best examples from the past of the role of greenhouse gas forcing in changing the state of the climate system. The early Eocene is characterized by above-freezing temperatures in polar winter, and tropical temperatures not substantially greater than today. Increases in the vigor of the hydrological cycle and meridional latent heat transport have frequently been cited as the cause of this distribution. We have carried out long (thousands of years), fully coupled, quasi-equilibrated, simulations of Eocene climate with NCAR's CCSM 1.4 (paleoCSM) with a range of carbon dioxide concentrations and with realistic Eocene vegetation, topographic, and bathymetric boundary conditions. The key result is substantial high latitude warming with little-to-no warming in the eastern equatorial Pacific. We discuss the relative importance of changes in local radiative balance, meridional heat transports, especially latent heat fluxes, and ocean heat transports in maintaining this state. Our results do not support a role for increased latent heat transport in maintaining "low gradient" climates.

PP62B MCC: 104 Saturday 1330h

Paleoclimate, Global Change, and the Future II *(joint with C, A, OS, GC)*

Presiding: **K Alverson,** PAGES International Project Office**; R Bradley,** University of Massachusetts**; T Pedersen,** University of British Columbia

PP62B-01 1330h INVITED

The Last 400 Kyr History of Greenhouse Trace Gases : What do we Learn in the Context of Future Changes.

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The Earth experienced major changes in its atmospheric composition over the past. The ice core record of atmospheric trace gases is now well documented for the period covering the last four glacial cycles which encompass a wide spectrum of climatic conditions. Past climate variations are not an exact analogue for future changes. However the past provides lessons from real experiments that the earth-system has undergone in terms of trace gas - climate and carbon cycle - climate interactions.

The greenhouse trace gas record (CO_2, CH_4, and partially N_2O) impressively demonstrates that present-day atmospheric concentrations are unprecedented for over 400,000 years. It provides tests for climate models intended to simulate future responses to increasing concentrations in greenhouse gases.

The CO_2 and $\delta^{13}C$ ice-core records have the potential to provide boundary conditions and constraints for biospheric and oceanic models used to estimate the uptake of anthropogenic carbon by terrestrial and oceanic sinks.

Recently it has been demonstrated that the gas ice-core record contains not only a signature of the changes in atmospheric concentrations, but also of the temperature changes. This property will accurately reveal the link and timing of greenhouse gas emission or uptake with climate changes.

PP62B-02 1345h

Interglacial Climate and Duration in the Past and Future

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