kyr B.P. These ages are close to those for Heinrich events 5, 3, 2, and 1, although uncertainties in the timescales of both the Owens and the marine cores do not allow detailed intercorrelation. The eastern Sierra events close to the time of H1 are the best dated and clearly show that major glacial advances preceded, as well as followed, the Heinrich event. The core dating suggests that similar timing may also have characterized the earlier advances. If this can be confirmed, it might indicate that the Heinrich events were a response to global climatic forcing rather than the instigator of global climate fluctuations.

4:00 PM Hostetler, Steve

CLIMATIC CONTROLS OF WESTERN U.S. ALPINE GLACIERS AT THE LAST GLACIAL

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We use the NCAR regional climate model (RegCM) to estimate the net mass balance of LGM mountain glaciers in the western U.S. Sensitivity tests suggest that, for our simulated LGM climate, many of the glaciers exhibit a variable response to climate, but were generally more sensitive to changes in temperature than to changes in precipitation. This is particularly the case for glaciers in central Idaho and on theYellowstone Plateau. Glaciers in the northern Rocky Mountains existed under relatively cold July temperatures and low winter accumulation, reflecting anticyclonic, easterly wind flow off the Laurentide Ice Sheet. In contrast, glaciers that existed under relatively warmer and wetter conditions are located along the Pacific coast south of Oregon, where enhanced westerlies delivered higher precipitation than present. Between these two groupings lie glaciers that were controlled by a mix of cold and wet conditions attributed to the convergence of cold air from the ice sheet and moisture derived from the westerlies. Our results support arguments that temperature depression during the LGM probably played a larger role in lowering ELAs in the western U.S. than did increased precipitation, although the magnitude of LGM temperature depression required for steady-state mass balance varied from 6-16°C. Only the Sierra Nevada glaciers required a substantial increase in precipitation to achieve steady-state mass balance, while glaciers in the Cascade Range existed with decreased precipitation.

4:15 PM Clark, D. H.

GLACIAL AND CLIMATIC COMPLEXITIES IN THE AMERICAN CORDILLERA DURING THE YOUNGER DRYAS PERIOD

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Although cooling and glacier advances related to the Younger Dryas event (YD; 11,000 - 10,000 ^{14}C yr B.P.) are well established in the circum-North Atlantic region, evidence for coeval glacier advances in western North America is far more equivocal. Despite recent studies which conclude that glaciers in the American Cordillera advanced and retreated in synchrony during the YD, some areas, particularly in the Pacific mountains, show evidence for glacier contraction during this time. These results suggest that climatic patterns in North America during the final stages of Pleistocene glaciation were complex rather than uniform and monotonic, possibly driven by variations in effective moisture.

Minimum limiting radiocarbon dates for Recess Peak moraines, the last regional late-Pleistocene advance in the Sierra Nevada, CA, indicate that it ended before 11,190 ± 70 ^{14}C yr B.P. (i.e., predating the YD). There is no evidence for subsequent glaciation until the late Holocene. Initial palynologic work from alpine lake sediments deposited during YD time indicate that the period was cool but too dry for significant glaciation (Hemphill and Clark, 1996). Similar pollen studies in western Oregon do not show evidence for YD cooling (Grigg and Whitlock, 1996). Lake sediments related to paired late-glacial moraines, designated McNeely 1 and 2, in the Cascade Mtns. near Mt. Rainier, WA, provide the best age limits for alpine glacier advances in the region, demonstrating that glaciers there also retreated during the YD. Age constraints from tephras and lake sediments adjacent to the moraines indicate that the earlier McNeely 1 moraines were deposited before 11,320 ± 60 ^{14}C yr B.P. (i.e., before the YD), and that the subsequent McNeely 2 moraines were deposited between 9550 ± 55 and 8990 ± 40 ^{14}C yr B.P. (i.e., after the end of the YD)(Heine, 1996). Combined with paleoecology studies, the Sierran and Cascade studies both suggest that climate was cool but too dry for glaciers to advance during the YD.

Minimum radiocarbon dates from bulk sediments cored downstream of the Temple Lakes moraines in the Wind River Range, WY, indicate that the advance ended before 11,400 ± 630 ^{14}C yr B.P. (Zielinski and Davis, 1987), before onset of the YD. Cosmogenic ^{10}Be exposure ages for a correlative moraine suggest, however, that some may be related to the YD (Gosse *et al.*, 1995). Lake coring studies in the Front Range, CO (Menounos and Reasoner, 1996), and the Canadian Rockies (Reasoner et al., 1994) also may indicate small glacier advances during the YD. The contradictory results of these studies, when combined with those from marine sediment cores from the Pacific shelf, indicate either that current findings do not resolve late-glacial climate changes well, or that climatic conditions across western North America were complex during the YD period, variously causing glaciers to expand or contract.

4:30 PM Gillespie, A. R.

NEW EXPOSURE AGES SUPPORT ASYNCHRONISM BETWEEN ALPINE GLACIATION AND SEA-LEVEL FLUCTUATIONS, SIERRA NEVADA, CALIFORNIA

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Cosmogenic ^{10}Be and ^{26}Al exposure dates from granitic boulders exposed on moraine crests and debris-flow levees on fans downstream at Sawmill Canyon, Inyo County, test the hypothesis that the "last glacial maximum" (LGM) in the Sierra Nevada predated the maximum sea-level depression at ~21 ka, during marine δ^{18}O stage 2. Previous ^{39}Ar-^{40}Ar dates on a basalt flow underlying the Hogsback moraine, boulder weathering studies, and soil-development studies demonstrated that glaciers of Sawmill Creek advanced at least twice to similar maximum extents (ELA: ~3040 and ~2910 m) since 120 ka. These relationships indicated that: (1) the latter, less extensive glaciers correlate with the Tioga glaciation (~24 to ~14 ka); and (2) the earlier, more extensive, Hogsback glacier predated stage 2 significantly (stage 4?).

Nine ^{10}Be and three ^{26}Al exposure ages were calculated with the production rates (P) of Nishiizumi *et al.* (1989), which presumes Tioga deglaciation at 11 ka, correcting for geographic latitude and altitude (Lal, 1991) and magnetic field variability (Clapp and Bierman, 1995). The ^{26}Al and ^{10}Be ages agree within analytic precision. Ages for 6 boulders from the Tioga moraines and fans were 12.4-8.6 ka (±2 ka). Two boulders from the Hogsback gave ^{10}Be ages of 21.0 and 13.0 ka. A pre-Hogsback moraine, constrained by ^{39}Ar-^{40}Ar basalt dates to >130 ka, yielded ^{10}Be ages of 30 and 11 ka. These low ages are minima for the Hogsback and pre-Hogsback moraines. Furthermore, new independent ^{14}C dates for the Tioga glaciation suggest that P should be lowered: the dates cited above are too young. Recalculation according to Larsen *et al.* (1995) gives the older Hogsback date as 26.6±6.0 ka, still a minimum for the moraine, and probably greater than the time of maximum sea-level depression at 21 ka. The recalculated Tioga exposure dates are 10.4 -14.9 ka, close limits to Tioga deglaciation. The recalculated pre-Hogsback exposure dates are ~36 ka or less, distant minima for the moraine. Because the pre-Hogsback moraine, but not the younger moraines, were buried by basaltic cinders, we suspect that the Hogsback, like the Tioga, ages are likely to be close limiting ages for the moraine. Therefore, it appears that the Hogsback was deposited after stage 4, but perhaps before stage 2. Our findings, although still tentative, may bring the chronology at Sawmill Canyon into closer agreement with independent glacial chronologies at June Lake (^{14}C) and Bloody Canyon (^{36}Cl), ~140 km northwest. At both these localities there is evidence for pre-stage 2, extensive advances (~30 and >40 ka, respectively). We conclude that the maximum Sierran ELA depressions and minimum eustatic sea-level were asynchronous, with the former occurring one or more times before the latter during stage 2.

4:45 PM Gosse, J. C.

LATE PLEISTOCENE WIND RIVER RANGE ICE CAP RESPONSE LINKED TO NORTH ATLANTIC EVENTS? BE-10 EXPOSURE AGES SAY YES

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We have determined, using cosmogenic Be-10, that the maximum extent of the piedmont outlet glaciers on the west flank of the Wind River Range, WY, the deposition of their recessional moraines, and the deposition of a moraine in a cirque near the ice divide were coeval with three of the ice-rafting events recorded in North Atlantic marine sediments. All ages are based on a production rate of 5.40 Be-10 atoms per gram of quartz per year at sea level and high latitude that was adjusted for site latitude, altitude, and sample thickness, but not for erosion or snow cover. At present, this production rate is known to be accurate to within ~10%, and constant during the past 20 ka at this location to within 3%. Dates for boulders (2265 m asl) on the distal edge of the type-Pinedale terminal moraines (deposited during the maximum advance at the Last Glacial Maximum) range from 22.0 to 24.0 ka, and are coeval with Heinrich event H-2. Deposition of six recessional moraines (2323-2390 m asl) nested immediately behind the terminal moraines range in age from 18.6 to 15.9 ka; their mean age, 17.6 ka (n=10, std. dev. =0.8 ka), falls within H-1. It is uncertain whether these recessional moraines represent a true readvance or were simply deposited during retreat from the terminal. The Inner Titcomb Lakes moraine (3231 m asl) yields a mean age of 12.4 ka (n=9) and is contemporaneous with the North Atlantic Younger Dryas event.

It appears that the Wind River Range ice masses responded to short-term changes in local climate (precipitation or temperature) that are linked to the hypothesized cyclic fluctuations in the geometry of the Laurentide Ice Sheet. Be-10 exposure dates from alpine moraine systems along the eastern flank of the Argentine Andes (now being determined) will be reported and compared to the results from North America.

TUE pm

5:00 PM Hostetler, Steve

CLIMATIC SENSITIVITY OF WESTERN NORTH AMERICA TO LAURENTIDE ICE SHEET PERTURBATIONS

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We are applying a coupled atmospheric modeling system to assess the role of the Laurentide Ice Sheet (LIS) as a component of abrupt climate perturbations, such as Heinrich events, that are recorded in marine and terrestrial records of western North America. The system is comprised of (1) an atmospheric general circulation model, the NCAR GENESIS model, run at a resolution of T31 (3.75 degrees lat. by 3.75 degrees long.) for the atmosphere and 2 X 2 (degrees lat. by degrees long.) for the surface, and (2) a regional climate model, the NCAR RegCM, run over western North America at a resolution of 60 km. Two 21 ka GENESIS experiments are being completed, one with a maximum size and height LIS, and one with a minimum LIS as represented by a collapse over the Hudson Bay region. For both experiments, sea surface temperatures were fixed. Preliminary analyses indicate the collapse of the ice sheet may have induced predominately regional temperature responses in both hemispheres, but particularly in the high latitudes of the Northern Hemisphere over North America, Europe, and Asia. Over the western and central US, the minimum LIS resulted in annual air temperatures that are some 2°C warmer than those simulated with the maximum LIS. The RegCM simulations will use boundary conditions derived from the GENESIS experiments. Results of both simulations will be presented.