Hudson and Quade Supplementary Information

SUPPLEMENTARY METHODS

Tufa Field Sampling and Preparation

Inorganic $CaCO_3$ tufa used for dating in this study is found in discrete laterally continuous sub-horizontal bands associated with most shoreline ridges in both the Ngangla Ring Tso and Drebyer Tsaka basins (Fig. 1). Full thickness samples were taken from bedrock encrustations at two discrete sampling localities in each basin. In the Ngangla Ring Tso basin, the six radiocarbon dates constraining the age of the paleoake highstand come from two separate locations on opposite sides of the paleolake. The Drebyer Tsaka samples similarly come from two locations on the high shoreline on the southwestern side of the salt pan (Fig. DR1).

Tufas are generally formed at or near closed-basin lake shorelines over multiple generations that can have large differences in age, so subsampling is necessary to correctly determine the age of individual phases of tufa growth. In the laboratory each tufa sample was cut into cross-section using a lapidary saw to expose the internal stratigraphy. Typically two or three distinct generations of tufa growth ranging between 3-50 mm in thickness were observed in each sample divided by a clear stratigraphic break (Fig. DR2). Each stratigraphic unit was subsampled for dating.

Radiocarbon Dating

All tufa subsamples were rinsed ultrasonically after sampling to remove any detritus and reacted in 2% H_2O_2 for 3 hours to remove any organic material. Samples were then rinsed ultrasonically again and dried overnight in a 70°C drying oven.

A chunk of approximately 15 mg of each sample was placed in a glass y-tube with 2-3 mL of 100% H_3PO_4 and evacuated to $<2x10^{-5}$ torr pressure. The sample was then combined with

the acid and dissolved until the reaction was visibly complete. Sample CO_2 gas was extracted under vacuum and cryogenically purified, passed through a 600°C Cu/Ag furnace to further remove contaminant gases, frozen in liquid nitrogen (LN), split into aliquots for $\delta^{13}C$ and AMS measurement and sealed in glass tubes. Purified CO_2 samples were then graphitized using 100 mg of zinc powder and Fe powder in a 2:1 proportion to the mass of carbon in the sample.

AMS and $\delta^{13}C$ measurements were performed by the Arizona Accelerator Mass Spectrometer Facility. Raw radiocarbon ages (^{14}C yrs BP) were converted to calendar ages (cal yrs BP where Present = AD 1950) using the Calib 6.0 software using the IntCal09 radiocarbon calibration curve (Reimer et al., 2009).

U-Th Dating

Tufa subsamples used for U-Th dating were slabbed, sampled based on stratigraphy, and pretreated identically to radiocarbon samples. U-Th dating was performed at the University of Minnesota. Sample powders were drilled using a carbide-tipped drill bit from the same stratigraphic tufa horizon from which radiocarbon samples were taken and prepared following the methods of Cheng et al. (2000a, 2009) and Shen et al. (2002). Samples were analyzed using a Neptune multi-collector ICP-MS. Uncertainties on concentrations are estimated as ±1% to reflect uncertainties in spike concentration and weighing rather than only analytical uncertainties. Ages were calculated using the ^{230}Th and ^{234}U half-lives of Cheng et al. (2000b) and the ^{238}U half-life of Jaffey et al. (1971). The detrital ^{230}Th correction for age calculations assumes the initial atomic ratio of $4.4(\pm2.2)x10^{-6}$. Those are values for a material at secular equilibrium with the bulk earth $^{232}Th/^{238}U$ value of 3.8. The error in initial ratio is arbitrarily assumed to be 50%. U-Th dates were finally corrected to AD 1950 to be consistent with the ^{14}C dates used to assess the reservoir effect (Table DR2).

GIS Watershed Analysis

The watershed boundaries, basin-averaged precipitation, modern lake areas and paleolake areas were measured using ESRI ArcGIS 10 software. All calculations used an equal-area conic projection covering the Asian continent. Modern basin boundaries were digitized manually using the 3-arc second (approximately 90m grid) Shuttle Radar Topography Mission Digital Elevation Model (SRTM DEM) and Google Earth imagery for verification of drainage patterns. Basin-averaged annual precipitation was determined using the mean annual TRMM (Tropical Rainfall Measuring Mission) precipitation averaged over 1998-2009 for each 0.25°x0.25° grid square intersecting a basin (Kummerow et al, 1997). The grid square values were then averaged to derive a single basin-averaged estimate.

Due to a large increasing trend in modern lake areas evident since ca. 1998 identified in most studied lake systems from sequential Landsat imagery, 'modern' lake areas used for analysis were extracted from Landsat imagery taken during 1999-2001 using a maximum-likelihood image classification method. If late 2000's images are used however, the resulting paleolake expansion pattern is similar. Lakes within each basin with greater than 0.25 km^2 area were retained and summed to calculate the final lake area estimate (Table DR3). Maximum paleolake areas for each lake system were extracted by measuring the elevation of the highest visible paleoshoreline with good preservation (visible at the same elevation on all sides of the basin) in no less than three locations on the imagery. These shorelines could generally be traced around >80% of the perimeter of the paleolake. The paleolake extent was determined by extracting cells with equal or less elevation than the paleolake shoreline from the DEM similar to the method used in the PaleolakeR tool developed by Sheng (2009). Modern lake areas not

subsumed by the highstand paleolake, including hydrologically open lakes flowing to the closed terminal lake were added to the paleolake area for the final summed area estimates (Table DR4).

The basin, 'modern' and highstand paleolake area data were analyzed to define the spatial pattern of lake expansions on the interior of the Tibetan Plateau by calculating the lake area ratios (*Aw* hereafter), the ratio of summed lake or paleolake areas to the total basin area for each lake system. This includes the areas of all water bodies hydrologically open or closed within a basin that are part of the hydrologic budget of the system. This approach is commonly implemented in hydrologic budget modeling (e.g. Matsubara and Howard, 2009) and effectively normalizes lakes and basins of vastly differing size to a measure of the net hydrologic budget. It also allows comparison between modern and paleolake systems with different basin configurations, and has been shown to be a reliable indicator of hydrologic budget in complex multi-lake systems (Benson et al., 1989). In a number of cases, the large paleolake areas observed define paleolakes that spill into or subsume adjacent basins (Table DR5). In this case, the paleolake and paleobasin areas were summed for each composite system and compared against a weighted average of the modern *Aw*'s for the basins included, weighted by basin area. For all analysis, lake systems with basins less than 500 km^2 were excluded to minimize the effect of basin geometry on the lake area-to-volume relationship.

Review of Holocene Monsoon Proxy Records

Figure DR4 shows the location of Holocene lake records on the Tibetan Plateau cited in the text, and the age range in which rainfall conditions inferred from proxy and/or shoreline reconstructions were much greater than present. References and relevant information about each record can be found in Table DR6.

Supplementary References

Benson, L.V., and Paillet, F.L., 1989, The use of total lake-surface area as an indicator of climatic change: examples from the Lahontan Basin: Quaternary Research, v. 32, p. 262-275.

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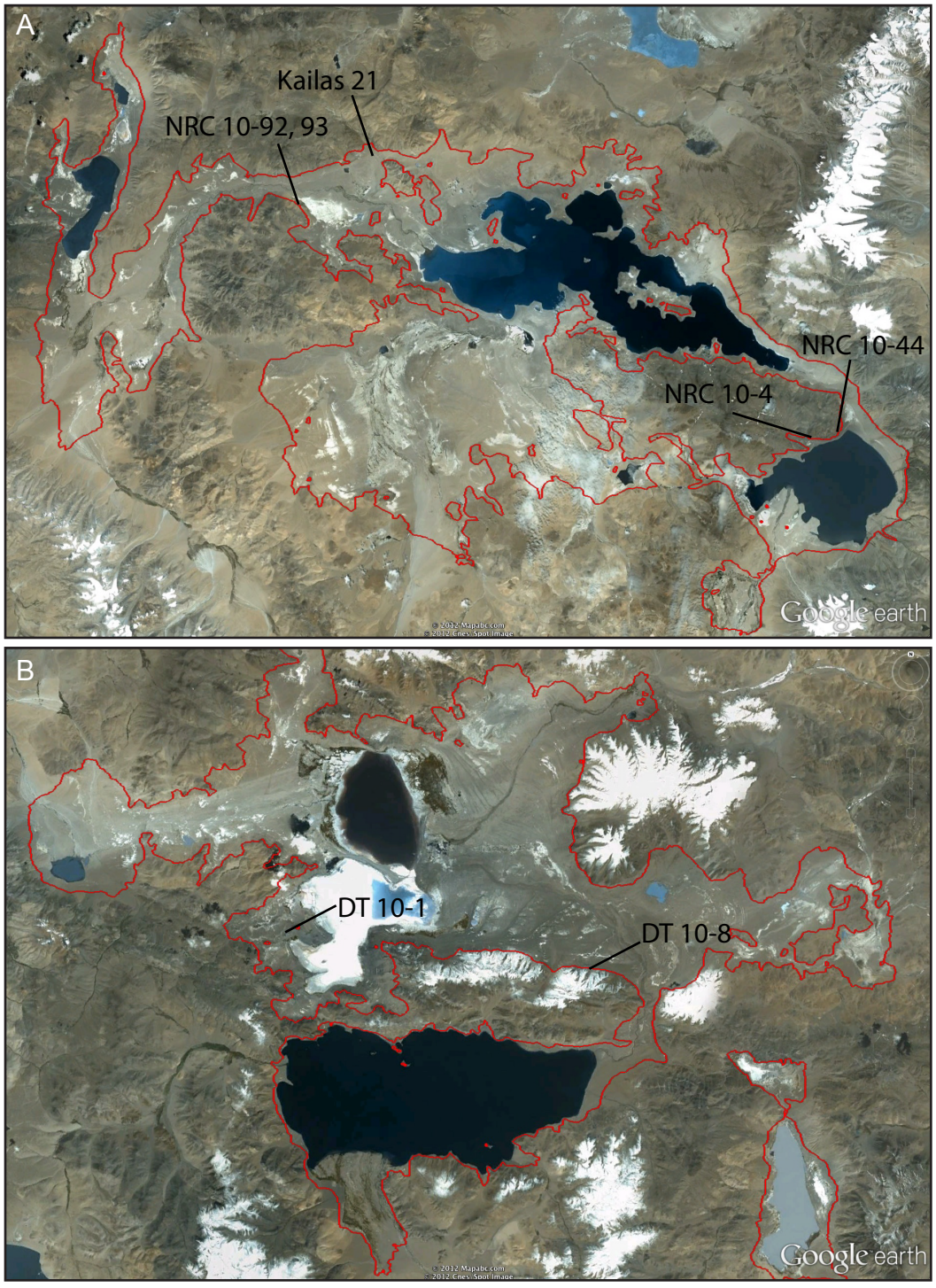
Supplementary Figure Captions

Figure DR1. Sampling locations in the Ngangla Ring Tso and Drebyer Tsaka basins for shoreline tufa samples. Paleolake high shoreline used for analysis shown in red. Google Earth image base. Dating results are given in Tables DR1 (^{14}C) and DR2 (U/Th series).

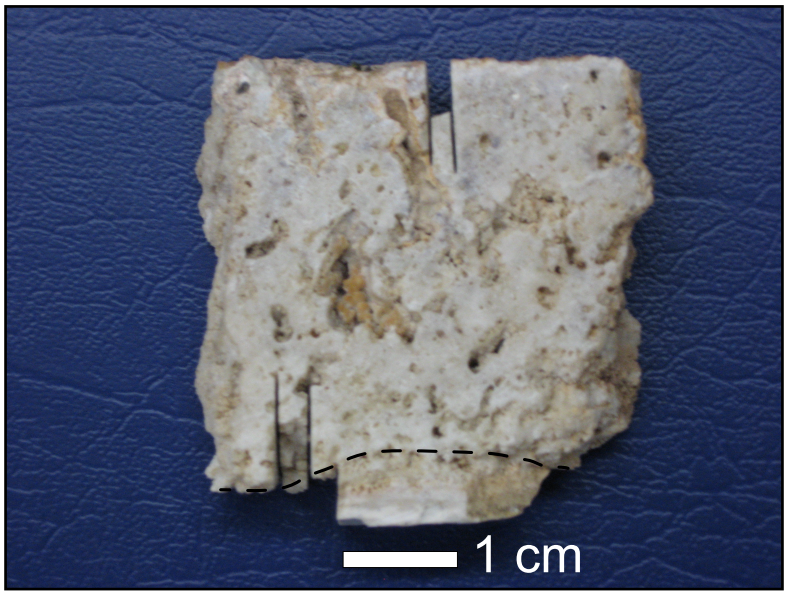
Figure DR2. Example tufa sample cross section showing two distinct periods of tufa growth separated by the black line. Each stratigraphic horizon was subsampled prior to dating.

Figure DR3. Results of regression analysis of paleolake expansion magnitudes. Glaciated basins are shown by white squares, unglaciated basins by black diamonds. Regression lines are shown in black. A) Paleolake elevation, B) mean basin elevation (SRTM), C) mean slope of the region covered by the paleolake highstand. Raw data are given in Tables DR4 and DR5.

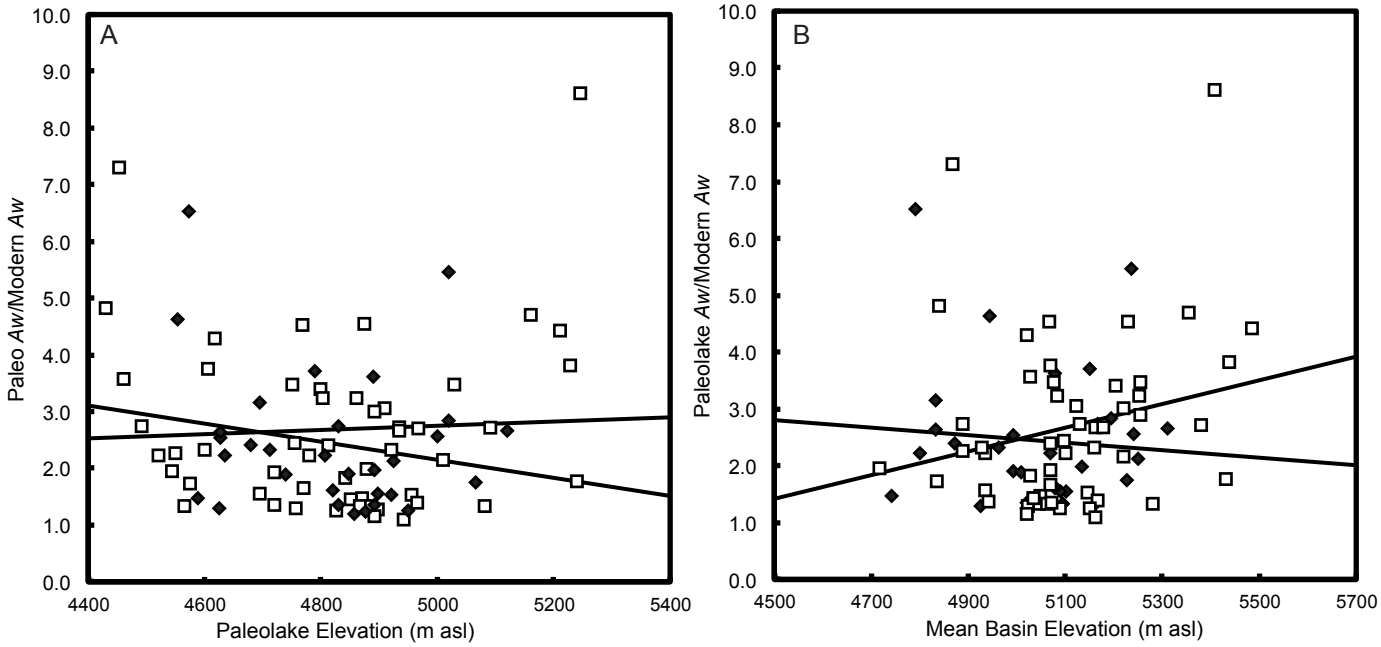
Figure DR4. Map showing climate proxy records of monsoon rainfall strength during the Holocene, and the time interval of inferred maximum wetness. References for each record are found in Table DR6.



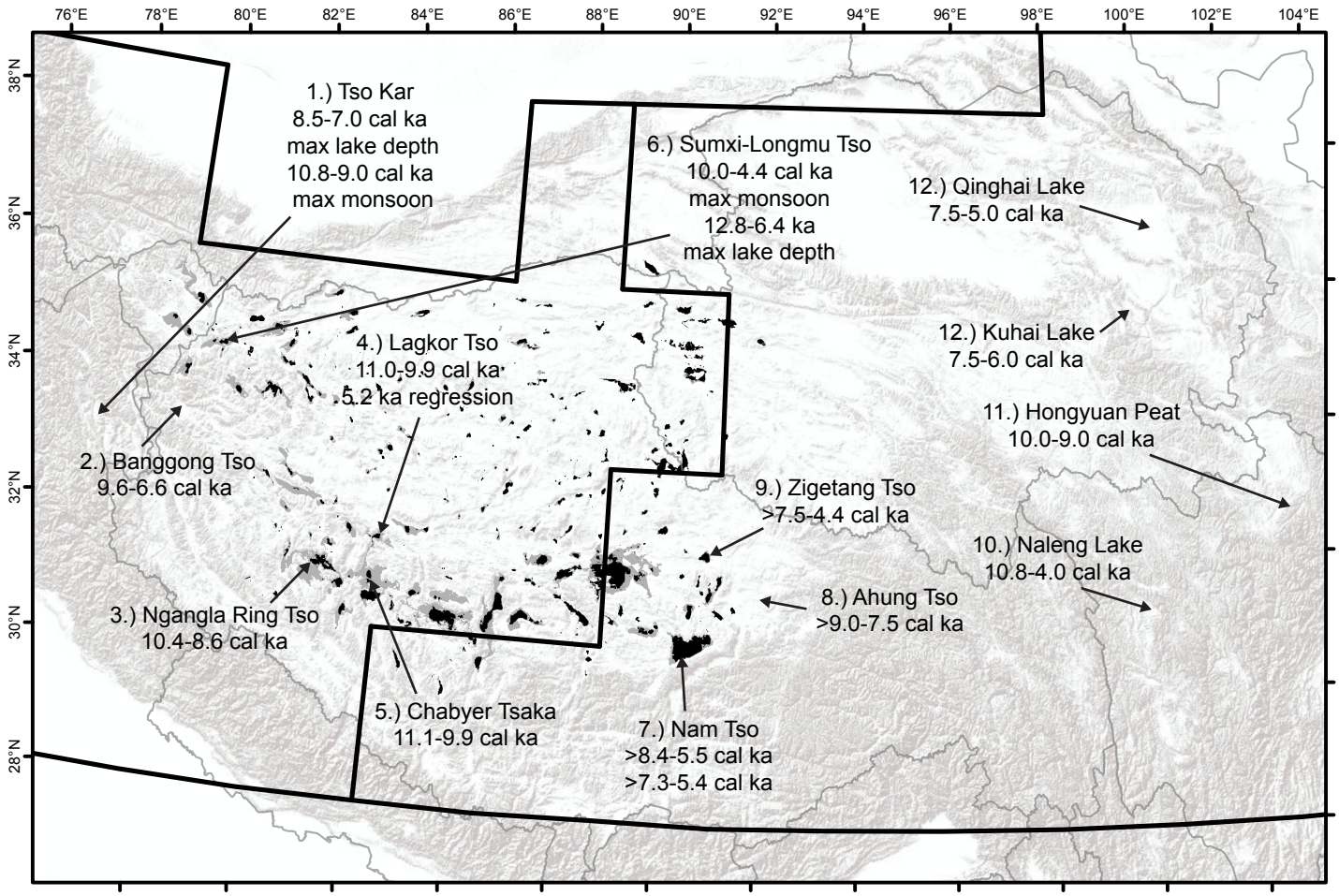
Hudson Figure DR1



Hudson Figure DR2



Hudson Figure DR3



Hudson Figure DR4

TABLE DR1. RADIOCARBON RESULTS

Sample Name	Laboratory ID	Lake Basin	Shoreline elevation (m asl)	^{14}C age (^{14}C yrs BP)	Uncertainty (^{14}C yrs BP)	2-sigma calibrated range* (calendar yrs BP)	Median age (calendar yrs BP)
nrc 10-92a	AA-91437	Ngangla Ring Tso	4862	8910	30	9,920-10,176	10,048
nrc 10-92b top	AA-91439	Ngangla Ring Tso	4862	8110	30	8,986-9134	9,060
nrc 10-92b bottom	AA-91434	Ngangla Ring Tso	4862	8370	30	9,306-9470	9,388
nrc 10-4-1 top	AA-96571	Ngangla Ring Tso	4862	7840	20	8,577-8,646	8,612
nrc 10-4-1 bottom	AA-96570	Ngangla Ring Tso	4862	8450	40	9,422-9,532	9,477
nrc 10-44-1	AA-96572	Ngangla Ring Tso	4864	8540	30	9,479-9,549	9,514
nrc 10-44-2	AA-96573	Ngangla Ring Tso	4864	8760	30	9,626-9,903	9,765
Kailas 21a†	**AA-82149**	**Ngangla Ring Tso**	**4823**	**7100**	**40**	**7,848-8,000**	**7,924**
Kailas 21c	**AA-82150**	**Ngangla Ring Tso**	**4823**	**7340**	**40**	**8,022-8,299**	**8,160**
dt 10-1a	AA-98073	Drebyer Tsaka	4585	8830	40	9,703-10,152	9,928
dt 10-8a	AA-99058	Drebyer Tsaka	4599	9780	50	11,121-11,266	11,193

*Calibration was performed using the Calib 6.0 software and the IntCal09 calibration curve (Reimer et al., 2009), median age is the arithmetic median of the 2-sigma range

†Samples shown in bold were used for determining the ^{14}C reservoir effect for tufa in the Ngangla Ring Tso lake system

TABLE DR2. U-Th SERIES RESULTS

Sample Number	^{238}U (ppb)	^{232}Th (ppb)	^{230}Th / ^{232}Th (activity)	$^{234}U/^{238}U$ (activity)	^{230}Th / ^{238}U (activity)	^{230}Th Age (yr) (uncorrected)	^{230}Th Age (yr)* (corrected)	^{230}Th Age (yr BP) (Before AD 1950)
Kailas 21a	19255.9 ±89.0	328.9 ±6.6	19.80 ±0.69	1.514 ±0.003	0.1104 ±0.0006	8224 ±51	7898 ±236	7839 ±236
Kailas 21c	15696.7 ±80.9	279.5 ±5.6	18.59 ±0.65	1.502 ±0.003	0.1081 ±0.0006	8112 ±52	7769 ±248	7710 ±248
nrc 10-93-2	2908.0 ±4.5	20.9 ±0.4	476.89 ±16.60	1.246 ±0.002	1.1183 ±0.0022	211396 ±1548	211251 ±1549	211191 ±1549

*Corrected ^{230}Th ages assume the initial $^{230}Th/^{232}Th$ atomic ratio of $4.4\pm2.2 \times 10^{-6}$. Those are the values for a material at secular equilibrium, with the bulk earth $^{232}Th/^{238}U$ value of 3.8. The errors are arbitrarily assumed to be 50%.

TABLE DR3. MODERN LAKES

	Lake Name[†]	Lake ID	Centroid Latitude (°N)	Centroid Longitude (°E)	Terminal Lake Elevation (m asl)	Peak Basin Elevation (m asl)	Mean Basin Elevation (m asl)	Mean Annual[§] Precipitation (mm/yr)	Lake Area (km^2)	Basin Area (km^2)	*Aw* (%)
Nonglaciated Headwaters	Tso Nag	1	31.63	82.33	4790	6165	5178	225	58.17	1100.84	5.28
	Qagong Co	2	34.43	82.34	5095	5931	5311	125	22.6	643.15	3.51
	Unnamed	3	34.03	82.61	4482	5862	5095	108	21.67	633.07	3.42
	Baqan Co	4	31.93	82.78	4964	5955	5237	239	13.19	688.48	1.92
	Tuoheping Lake	5	33.98	82.95	4947	6133	5240	126	102.92	3495.20	2.94
	Kyahu Co	6	33.39	82.97	4772	6140	5150	147	27.56	2525.15	1.09
	Wanquan Lake	7	34.08	83.68	4871	5994	5135	138	121.42	5345.51	2.27
	Larbu Co	8	32.95	83.81	4547	5636	4790	156	16.36	1365.23	1.20
	Lagkor Co	9	32.03	84.13	4467	6075	4871	245	105.08	4193.48	2.51
	Chagbo Co	10	33.33	84.12	4513	6048	4943	161	57.36	6026.83	0.95
	Xin Lake	11	34.39	84.25	4813	6111	5165	116	41.86	2225.22	1.88
	Rena Co	12	32.73	84.26	4594	5555	4832	200	18.65	508.39	3.67
	Domar Co	13	32.97	84.46	4675	5404	4832	200	12.93	531.88	2.43
	Unnamed	14	34.53	84.70	5058	5778	5227	136	22.97	1233.09	1.86
	Wuming Lake	15	33.95	85.33	4813	5903	5081	152	11.36	809.41	1.40
	Nagding Co/Nanbei Co	16	32.67	85.45	4869	5627	5076	241	19.71	1231.98	1.60
	Ningri Co	17	33.32	85.58	5035	6066	5275	209	15.66	903.33	1.73
	Gyado Co	18	34.04	85.61	4880	5826	5095	171	40.74	1036.05	3.93
	Unnamed	19	32.45	85.77	4595	5620	4993	298	12.91	549.21	2.35
	Gom Caka	20	33.66	85.81	4678	6077	5020	202	66.34	6729.68	0.99
	Bezi Co	21	33.03	86.17	4841	5865	5091	332	17.75	1592.48	1.11
	Rigain Punco	22	32.58	86.24	4672	5695	4963	251	42.12	1390.24	3.03
	Marye Co	23	33.53	86.34	4860	5772	5064	228	7.01	467.68	1.50
	BunSum Co	24	33.21	86.43	4915	5973	5250	217	10.08	956.75	1.05
	Unnamed	25	31.91	87.21	4492	6006	4754	284	12.13	697.11	1.74
	Chaoyang Lake	26	35.29	87.26	4744	5518	4958	156	44.2	3385.39	1.31
	Deyu Co	27	35.69	87.26	4852	5589	5021	148	69.86	2109.41	3.31
	Qoiden Co	28	34.36	87.49	4883	5647	5091	214	30.73	1328.33	2.31
	Xiangyang Lake	29	34.00	87.55	5011	5590	5194	217	11.78	894.82	1.32
	Pibi Lake	30	34.33	87.70	4894	5870	5102	199	35.45	1651.12	2.15
	Xo Caka	31	33.06	87.78	4800	5828	5069	245	24.35	1513.68	1.61
	Haobo Co/Yingwu Co	32	34.41	88.03	4830	5569	5022	209	42.99	1227.27	3.50
	Pongyin Co	33	32.92	88.26	4727	5870	5006	295	52.76	1611.05	3.27
	Longwei Co	34	33.87	88.31	4946	5659	5159	241	48.77	1085.39	4.49
	Bandao Lake	35	34.16	88.44	4917	5648	5087	235	36.29	1217.20	2.98
	Pongce Co/Naiqam Co	36	32.32	88.69	4522	5582	4864	301	103.64	4645.50	2.23
	Belog Co	37	32.90	88.84	4818	5431	5005	268	25.03	773.31	3.24
	Geigain Co	38	32.40	89.19	4667	5358	4872	282	26.6	1487.06	1.79
	Dongyue Lake	39	34.38	89.21	4846	5781	5060	341	20.57	548.40	3.75
	Zainzong Co	40	32.19	89.48	4516	5124	4639	312	10.23	610.29	1.68
	Pangkog Co	41	31.75	89.51	4527	5576	4717	313	129.97	2466.30	5.27
	Angdar Co	42	32.71	89.58	4839	5512	4992	272	43.16	1377.30	3.13
	Zhamcomarqong	43	33.15	89.70	4898	5456	4990	258	20.35	603.00	3.37
	Namka Co	44	31.86	89.79	4537	5255	4676	287	23.55	1360.83	1.73
	Yaggain Canco	45	33.01	89.79	4872	5645	5019	274	113.16	2958.30	3.83
	Kyebxang Co	46	32.45	89.98	4614	5638	4926	304	157.02	2621.31	5.99
	Dungqag Co	47	31.77	90.41	4620	5653	4801	361	53.19	1396.49	3.81
	Mingjing Lake	48	35.06	90.56	4801	5577	4967	255	115.47	2760.42	4.18
	Bam Co	49	31.25	90.58	4560	5621	4852	370	211.75	3772.68	5.61
	Zigetang Co	50	32.08	90.86	4568	5693	4742	350	209.22	3479.00	6.01
Glaciated Headwaters	S. Salijlang Kol	51	34.68	79.69	5187	6328	5407	132	116.85	5162.61	2.26
	Chem Co	52	34.15	79.78	4961	6447	5485	165	113.84	1813.41	6.28
	Aksayqin Lake/Gozha Co	53	35.31	79.83	4844	7057	5252	135	467.12	17460.60	2.68
	Sumxi Co/Longmu Co	54	34.61	80.46	5003	6653	5354	136	150.26	3260.50	4.61
	Gyeze Caka	55	33.95	80.91	4525	6583	5098	190	106.03	2689.34	3.94
	Bamgdog Co/Pur Co/Yaeya Lake	56	34.95	81.56	4904	6335	5254	122	285.77	6991.35	4.09
	Lumachangdong Co	57	34.02	81.62	4812	6514	5240	145	358.44	8123.88	4.41
	Qingche Lake/Luotuo Lake	58	34.74	81.89	5039	6332	5255	132	209.7	2457.80	8.53
	Argog Co	59	30.98	82.24	5116	6070	5390	264	59.71	1203.86	4.96
	Memar Co/Aru Co	60	34.22	82.31	4920	6387	5202	132	241.72	2339.32	10.33
	Nyer Co/A'ong Co	61	32.55	82.46	4381	6697	4867	184	271.21	46885.50	0.58
	N. Heishi Lake	62	35.56	82.75	5049	6907	5381	103	94.17	1732.49	5.44
	Bero Zeco	63	34.73	82.93	4402	6202	5008	227	35.5	4318.00	0.82
	Ngangla Ring Co	64	31.54	83.08	4727	6449	5201	235	514.43	11549.60	4.45
	Jianshui Lake/Bairab Co	65	25.30	83.12	4905	6338	5159	103	256.39	9739.63	2.63
	Gopug Co	66	31.86	83.18	4718	6546	5066	210	67.29	2315.84	2.91
	Darab Co	67	32.47	83.21	4433	6138	4808	190	35.23	2869.00	1.23
	Unnamed	68	33.96	83.32	4884	6055	5123	121	23.26	1949.43	1.19
	Rinchen Shubtso	69	31.28	83.45	4760	6632	5294	233	181.855	2432.46	7.48
	Ca Co	70	32.11	83.55	4340	6544	5028	259	95.12	2720.65	3.50

	Palung Co	71	30.88	83.58	5101	6544	5439	281	143.43	1609.66	8.91
	Yang Lake	72	35.41	84.60	4792	6188	5083	125	80.97	9141.18	0.89
	Taro Co/Drebyer Tsaka	73	31.42	84.06	4567	6568	5071	246	705.16	15493.50	4.55
	Dong Co/Zhaxi Co	74	32.18	84.73	4394	6756	4840	251	131.5	8189.23	1.61
	Gyesar Co	75	30.20	84.78	5198	6293	5558	238	141.97	954.36	14.88
	Camar Co/Burgar Co	76	33.31	84.81	4581	6271	5021	177	64.68	6343.41	1.02
	Yunbo Co/Garing Co	77	30.77	84.95	4645	6356	5178	265	125.73	3275.61	3.84
	Dawa Co	78	31.23	85.00	4625	6511	5050	290	111.23	2538.32	4.38
	Larung Co/Laxong Co	79	34.34	85.23	4862	6410	5164	165	72.63	2168.28	3.35
	Zhari Namco	80	30.87	85.50	4612	6511	5065	277	1073.78	18407.10	5.83
	Unnamed	81	29.85	85.70	5145	6225	5434	415	107.05	761.87	14.05
	Bura Co	82	34.40	85.77	5166	6501	5432	182	88.74	648.19	13.69
	Larxang Co	83	33.98	86.04	4971	6378	5191	172	22.83	1430.69	1.60
	Punze Co	84	30.47	86.11	4964	6064	5175	288	31.99	638.14	5.01
	Monco Bunnyi	85	30.67	86.22	4684	6190	5068	316	143.59	820.05	17.51
	Xum Co	86	30.29	86.41	4714	6531	5162	298	206.8	1933.03	10.70
	Garkung Caka	87	33.97	86.49	4909	6086	5129	174	47.95	1704.65	2.81
	Tangra Yumco	88	31.07	86.60	4535	6600	5099	305	823.09	9004.42	9.14
	Yumgen Co/Gyaro Co/Gyungmo C	89	32.19	86.60	4472	6122	4888	286	41.29	2498.00	1.65
	Gangtang Co	90	33.19	86.67	4861	6162	5220	234	10.38	558.58	1.86
	Suana Lake	91	33.91	86.69	4822	6055	5026	185	28.32	1040.96	2.72
	Yurbao Co/Dapeng Lake	92	35.74	86.69	4889	6345	5151	152	73.96	1353.50	5.46
	Tangqung Co	93	31.57	86.74	4460	6313	4948	298	53.78	899.86	5.98
	Yi'bug Caka	94	32.98	86.74	4560	6259	5062	249	167.47	6960.87	2.41
	Tanshui Lake/Margai Caku	95	35.12	86.75	4801	6353	5069	163	201.93	9481.25	2.13
	Raggyor Caka	96	33.69	86.84	4755	6152	5020	272	24.92	972.76	2.56
	Margog Caka	97	33.86	87.02	4836	5986	5058	216	90.52	2606.57	3.47
	Co Nyi/Tawa Co	98	34.55	87.18	4930	6422	5160	195	102.99	3881.80	2.65
	Unnamed	99	32.35	87.31	4977	6201	5221	316	43.93	775.85	5.66
	Gomang Co/Zhangne Co	100	31.56	87.33	4605	5992	4929	299	98.55	1472.25	6.69
	Ngangzi Co/Marxai Co	101	30.97	87.47	4685	6030	5044	342	483.67	8953.81	5.40
	Dogze Co/Tomgo Co	102	31.90	87.54	4465	6296	4948	329	319.91	10521.50	3.04
	Baidoi Co	103	32.78	87.82	4758	6099	5100	352	61.95	2207.33	2.81
	Norma Co	104	32.39	88.05	4700	6144	5066	304	71.79	1405.43	5.11
	Kungkung Caka/Qagain Co	105	33.16	88.11	4760	6047	5067	266	76.23	2773.98	2.75
	Gyarab Co/Serbug Co	106	32.00	88.22	4515	6209	4889	301	105.89	3431.62	3.09
	Rola Tso/Tanshui Lake	107	35.45	88.39	4821	6005	5020	196	102.61	4579.32	2.24
	Peli Co	108	32.90	88.44	4819	6287	5053	291	24.3	690.34	3.52
	Linggo Co	109	33.85	88.60	5069	6259	5280	298	103.52	1856.60	5.58
	Darngo Co/Amur Co	110	33.50	88.70	4964	6084	5169	242	82.06	2656.45	3.09
	Ngoinyar Coqung	111	32.98	88.70	4825	6290	5095	268	63.95	1347.08	4.75
	Baitan Lake	112	34.58	88.96	4823	6458	5088	270	417.09	7709.24	5.41
	Seling Co	113	31.79	88.99	4539	6410	4934	353	3816.04	50039.30	7.63
	Cedo Caka/Terang Puno	114	33.17	89.04	4848	6118	5032	270	72.72	3054.09	2.38
	Dogaicoring Qangco	115	35.32	89.24	4792	6263	5012	218	214.08	6086.54	3.52
	Xiangyang Lake	116	35.80	89.42	4866	5786	5050	248	87.09	1852.36	4.70
	Jingyu Lake	117	36.33	89.44	4717	6005	4941	164	250.04	4767.46	5.24
	Meriqancomari	118	33.64	89.72	4952	6219	5149	284	67.55	1598.50	4.23
	Tug Co	119	33.43	90.08	4936	6517	5161	303	1130.66	13078.10	8.65
	Lixi'oidaim Co	120	35.75	90.19	4876	6068	5045	231	224.03	1958.62	11.44
	Xijie Ulan Lake/Yonghong Co	121	35.21	90.34	4773	6131	4930	222	430.87	5859.59	7.35
	Ulan Ul Lake	122	34.83	90.43	4855	5878	5071	263	520.26	6493.55	8.01
	Nam Co	123	30.74	90.60	4724	6363	5024	397	1967.58	10836.40	18.16
	Daru Co	124	31.69	90.74	4683	5728	4934	324	58.54	589.17	9.94
	Pung Co/Npen Co	125	31.51	90.97	4529	6132	4829	403	295.28	3398.20	8.69
	Yinmar Lake, Hoh Xu Lake	126	35.59	91.14	4890	6015	5018	250	444.77	3348.31	13.28
	Dung Co/Kyiru Co	127	31.71	91.16	4551	5819	4805	387	144.13	1296.50	11.12
	Qoimo Co	128	33.89	91.19	4923	5823	5072	332	82.51	675.66	12.21
	Neri Yunco	129	31.30	91.47	4529	5763	4716	373	75.2	1168.02	6.44
	Codarima	130	35.33	91.86	4785	5404	4952	291	96.12	649.43	14.80
Composite Basins*	Mang Co	131	34.50	80.44	5018	6275	5315	--	--	400.74	--
	Unnamed	132	34.80	81.27	5000	5888	5173	--	--	512.63	--
	Yangparpen Co	133	32.24	89.61	--	--	--	--	--	638.14	--

*These lake basins are subsumed by a large composite paleolake, but were not used in the analysis of modern lakes, and are only included for comparison to those systems

†Lake names were taken from the map by Yao et al. (2008)

§Basin-averaged mean annual precipitation from TRMM data 1998-2009 (Kummerow et al., 1997)

TABLEDR4. PALEOLAKES

	Lake Name	Lake ID	Centroid Latitude (°N)	Centroid Longitude (°E)	Terminal Lake Elevation (m asl)	High Shoreline Elevation (m asl)	Lake Area (km^2)	Highstand Lake Area (km^2)	Total Basin Area (km^2)	Aggregate Lake *Aw* (%)	Highstand Lake *Aw* (%)	Highstand *Aw*/ Modern *Aw*	Mean Slope (°)	Mean Basin Elevation (m asl)
Unglaciated Headwaters	Qagong Co	2	34.43	82.34	5095	5120	22.6	60.04	643.15	3.51	9.34	2.66	1.095	5931
	Baqan Co	4	31.93	82.78	4964	5020	13.19	72	688.48	1.92	10.46	5.46	1.642	5955
	Tuoheping Lake	5	33.98	82.95	4947	5000	102.92	264.27	3495.2	2.94	7.56	2.57	1.201	6133
	Kyahu Co	6	33.39	82.97	4772	4789	27.56	102.23	2525.15	1.09	4.05	3.71	1.157	6140
	Wanquan Lake	7	34.08	83.68	4871	4891	121.42	239.75	5345.51	2.27	4.49	1.97	1.662	5994
	Larbu Co	8	32.95	83.81	4547	4572	16.36	106.74	1365.23	1.20	7.82	6.52	0.784	5636
	Chagbo Co	10	33.33	84.12	4513	4553	57.36	265.44	6026.83	0.95	4.40	4.63	0.735	6048
	Xin Lake	11	34.39	84.25	4813	4830	41.86	114.59	2225.22	1.88	5.15	2.74	0.943	6111
	Rena Co	12	32.73	84.26	4594	4626	18.65	49.03	508.39	3.67	9.64	2.63	1.38	5555
	Domar Co	13	32.97	84.46	4675	4695	12.93	40.8	531.88	2.43	7.67	3.16	1.126	5404
	Unnamed	14	34.53	84.7	5058	5065	22.97	40.05	1233.09	1.86	3.25	1.74	0.741	5778
	Wuming Lake	15	33.95	85.33	4813	4821	11.36	18.4	809.41	1.40	2.27	1.62	1.337	5903
	Nagding Co/Nanbei Co	16	32.67	85.45	4869	4890	19.71	71.37	1231.98	1.60	5.79	3.62	1.299	5076
	Gyado Co	18	34.04	85.61	4880	4892	40.74	54.61	1036.05	3.93	5.27	1.34	2.062	5826
	Unnamed	19	32.45	85.77	4595	4628	12.91	32.83	549.21	2.35	5.98	2.54	2.167	5620
	Rigain Punco	22	32.58	86.24	4672	4712	42.12	98.14	1390.24	3.03	7.06	2.33	1.537	5695
	BunSum Co	24	33.21	86.43	4915	4925	10.08	21.38	956.75	1.05	2.23	2.12	0.941	5973
	Deyu Co	27	35.69	87.26	4852	4854	69.86	83.25	2109.41	3.31	3.95	1.19	1.048	5589
	Xiangyang Lake	29	34	87.55	5011	5020	11.78	33.45	894.82	1.32	3.74	2.84	0.996	5590
	Pibi Lake	30	34.33	87.7	4894	4898	35.45	55.14	1651.12	2.15	3.34	1.56	0.941	5870
	Xo Caka	31	33.06	87.78	4800	4806	24.35	54.28	1513.68	1.61	3.59	2.23	0.919	5828
	Haobo Co/Yingwu Co	32	34.41	88.03	4830	4831	42.99	58.24	1227.27	3.50	4.75	1.35	0.532	5569
	Pongyin Co	33	32.92	88.26	4727	4739	52.76	99.93	1611.05	3.27	6.20	1.89	0.793	5870
	Longwei Co	34	33.87	88.31	4946	4949	48.77	61.71	1085.39	4.49	5.69	1.27	0.793	5659
	Bandao Lake	35	34.16	88.44	4917	4920	36.29	55.91	1217.2	2.98	4.59	1.54	0.867	5648
	Geigain Co	38	32.4	89.19	4667	4680	26.6	63.98	1487.06	1.79	4.30	2.41	0.843	5358
	Angdar Co	42	32.71	89.58	4839	4848	43.16	82.17	1377.3	3.13	5.97	1.90	0.803	5512
	Yaggain Canco	45	33.01	89.79	4872	4876	113.16	140.95	2958.3	3.83	4.76	1.25	0.734	5645
	Kyebxang Co	46	32.45	89.98	4614	4626	157.02	203.32	2621.31	5.99	7.76	1.29	0.877	5638
	Dungqag Co	47	31.77	90.41	4620	4635	53.19	118.09	1396.49	3.81	8.46	2.22	0.888	5653
	Zigetang Co	50	32.08	90.86	4568	4588	209.22	308.43	3479	6.01	8.87	1.47	1.196	5693
Glaciated Headwaters	S. Salijlang Kol	51	34.68	79.69	5187	5245	116.85	1007.12	5162.61	2.26	19.51	8.62	1.388	6328
	Chem Co	52	34.15	79.78	4961	5210	113.84	503.27	1813.41	6.28	27.75	4.42	4.47	6447
	Aksayqin Lake/Gozha Co	53	35.31	79.83	4844	4860	467.12	1515.77	17460.6	2.68	8.68	3.24	1.84	7057
	Qingche Lake/Luotuo Lake	58	34.74	81.89	5039	5105	209.7	606.74	2457.8	8.53	24.69	2.89	1.281	6332
	N. Heishi Lake	61	35.56	82.75	5049	5091	94.17	256.67	1732.49	5.44	14.82	2.73	1.458	6907
	Jianshui Lake/Bairab Co	63	25.3	83.12	4905	4920	256.39	597.03	9739.63	2.63	6.13	2.33	1.262	6338
	Gopug Co	64	31.86	83.18	4718	4768	67.29	305.11	2315.84	2.91	13.17	4.53	1.092	6546
	Unnamed	66	33.96	83.32	4884	4910	23.26	71.11	1949.43	1.19	3.65	3.06	0.926	6055
	Ca Co	68	32.11	83.55	4340	4460	95.12	339.47	2720.65	3.50	12.48	3.57	2.283	6544
	Palung Co	69	30.88	83.58	5101	5228	143.43	548.3	1609.66	8.91	34.06	3.82	2.481	6544

Yang Lake	70	35.41	84.6	4792	4803	80.97	261.95	9141.18	0.89	2.87	3.24	1.233	6188
Dong Co/Zhaxi Co	72	32.18	84.73	4394	4430	131.5	633.52	8189.23	1.61	7.74	4.82	1.391	6756
Camar Co/Burgar Co	74	33.31	84.81	4581	4617	64.68	277.73	6343.41	1.02	4.38	4.29	0.972	6271
Larung Co/Laxong Co	77	34.34	85.23	4862	4878	72.63	144.3	2168.28	3.35	6.66	1.99	0.891	6410
Bura Co	80	34.4	85.77	5166	5239	88.74	156.72	648.19	13.69	24.18	1.77	3.589	6501
Garkung Caka	85	33.97	86.49	4909	4935	47.95	131.07	1704.65	2.81	7.69	2.73	2.022	6086
Yumgen Co/Gyaro Co/Gyungmo Co	87	32.19	86.6	4472	4492	41.29	112.96	2498	1.65	4.52	2.74	1.005	6122
Gangtang Co	88	33.19	86.67	4861	4890	10.38	31.18	558.58	1.86	5.58	3.00	1.285	6162
Suana Lake	89	33.91	86.69	4822	4840	28.32	51.58	1040.96	2.72	4.96	1.82	1.586	6055
Yurbao Co/Dapeng Lake	90	35.74	86.69	4889	4895	73.96	93.54	1353.5	5.46	6.91	1.26	1.269	6345
Yi'bug Caka	92	32.98	86.74	4560	4565	167.47	225.2	6960.87	2.41	3.24	1.34	0.949	6259
Tanshui Lake/Margai Caku	93	35.12	86.75	4801	4812	201.93	485.92	9481.25	2.13	5.13	2.41	1.049	6353
Co Nyi/Tawa Co	96	34.55	87.18	4930	4934	102.99	273.85	3881.8	2.65	7.05	2.66	1.011	6422
Unnamed	97	32.35	87.31	4977	5010	43.93	94.6726	775.85	5.66	12.20	2.16	1.759	6201
Baidoi Co	101	32.78	87.82	4758	4780	61.95	138.09	2207.33	2.81	6.26	2.23	1.188	6099
Norma Co	102	32.39	88.05	4700	4720	71.79	138.56	1405.43	5.11	9.86	1.93	1.299	6144
Kungkung Caka/Qagain Co	103	33.16	88.11	4760	4771	76.23	126.72	2773.98	2.75	4.57	1.66	0.872	6047
Gyarab Co/Serbug Co	104	32	88.22	4515	4550	105.89	240.35	3431.62	3.09	7.00	2.27	1.998	6209
Linggo Co	107	33.85	88.6	5069	5081	103.52	137.97	1856.6	5.58	7.43	1.33	1.448	6259
Darngo Co/Amur Co	108	33.5	88.7	4964	4965	82.06	114.12	2656.45	3.09	4.30	1.39	0.72	6084
Baitan Lake	110	34.58	88.96	4823	4826	417.09	522.89	7709.24	5.41	6.78	1.25	1.108	6458
Cedo Caka/Terang Puno	112	33.17	89.04	4848	4850	72.72	106.07	3054.09	2.38	3.47	1.46	0.967	6118
Xiangyang Lake	114	35.8	89.42	4866	4870	87.09	129.18	1852.36	4.70	6.97	1.48	1.438	5786
Jingyu Lake	115	36.33	89.44	4717	4720	250.04	340.31	4767.46	5.24	7.14	1.36	0.8	6005
Meriqancomari	116	33.64	89.72	4952	4956	67.55	103.53	1598.5	4.23	6.48	1.53	0.939	6219
Tug Co	117	33.43	90.08	4936	4942	1130.66	1237.22	13078.1	8.65	9.46	1.09	1.129	6517
Lixi'oidaim Co	118	35.75	90.19	4876	4882	224.03	298.33	1958.62	11.44	15.23	1.33	1.084	6068
Ulan Ul Lake	120	34.83	90.43	4855	4865	520.26	706.21	6493.55	8.01	10.88	1.36	1.111	5878
Nam Co	121	30.74	90.6	4724	4756	1967.58	2574.58	10836.4	18.16	23.76	1.31	2.001	6363
Daru Co	122	31.69	90.74	4683	4694	58.54	91.43	589.17	9.94	15.52	1.56	1.266	5728
Yinmar Lake, Hoh Xu Lake	124	35.59	91.14	4890	4892	444.77	505.66	3348.31	13.28	15.10	1.14	1.248	6015
Neri Yunco	127	31.3	91.47	4529	4544	75.2	146.59	1168.02	6.44	12.55	1.95	1.027	5763

TABLE DR5. COMPOSITE PALEOLAKES

Lake Name	Lake ID	Centroid Latitude (°N)	Centroid Longitude (°E)	Terminal Lake Elevation (m asl)	High Shoreline Elevation (m asl)	Lake Area (km^2)	Highstand Lake Area (km^2)	Total Basin Area (km^2)	Aggregate Lake *Aw* (%)	Highstand Lake *Aw* (%)	Highstand *Aw*/ Modern *Aw*	Mean Slope (°)	Mean Basin Elevation (m asl)	Composite Lake ID's
Sumxi Co/Longmu Co	54	34.61	80.46	5003	5160	150.26	760.78	3260.50	4.96	23.33	4.70	2.303	5354	131
Gyeze Caka	55	33.95	80.91	4525	4800	106.03	1580.15	10813.22	4.30	14.61	3.40	3.312	5205	57
Bamgdog Co/Pur Co/Yaeya Lake	56	34.95	81.56	4904	5030	285.77	997.51	7503.98	3.83	13.29	3.47	1.700	5254	132
Memar Co/Aru Co	60	34.22	82.31	4920	4967	241.72	709.56	2972.39	8.86	23.87	2.69	1.685	5179	3
Nyer Co/A'ong Co	61	32.55	82.46	4381	4453	271.21	2500.57	54072.50	0.63	4.62	7.31	1.511	4867	63, 67
Ngangla Ring Co	64	31.54	83.08	4727	4875	514.43	3696.99	16286.76	5.00	22.70	4.54	2.177	5227	1, 69
Taro Co/Chabyer Caka	73	31.42	84.06	4567	4605	705.16	4057.90	23916.95	4.51	16.97	3.76	2.963	5070	9, 75, 77
Zhari Namco	80	30.87	85.50	4612	4750	1073.78	4993.07	22527.34	6.37	22.16	3.48	2.298	5076	78, 81, 85
Tangra Yumco	88	31.07	86.60	4535	4755	823.09	2649.23	11837.31	9.15	22.38	2.44	3.692	5098	86, 93
Dogze Co/Tomgo Co	102	31.90	87.54	4465	4520	319.91	956.75	12690.86	3.39	7.54	2.22	1.457	4935	25, 100
Seling Co	113	31.79	88.99	4539	4600	3816.04	10641.28	68316.28	6.70	15.58	2.33	1.702	4927	36, 40, 41, 44, 101, 132
Pung Co	125	31.51	90.97	4529	4575	295.28	1129.12	8467.38	7.69	13.33	1.73	1.324	4836	49, 127

TABLE DR6. TIBETAN PLATEAU PROXY RECORDS

Figure S4 #	Lake Name†	Lake ID	Latitude (°N)	Longitude (°E)	Inferred Wettest Period	Length of Record† cal ka	Methods Used	References
1.)	Tso Kar	n/a	33.3	78.0	8.5-7.0 cal ka	n/a	paleolake sediments/shorelines	Wunneman et al., 2011
					10.8-9.0 cal ka	15.2-present	terrestrial pollen	Demske et al., 2009
2.)	Banggong Tso	n/a	33.5	79.8	9.6-6.6 cal ka	~10.0-present	% $CaCO_3$, terrestrial pollen, diatoms, bulk carbonate $\delta^{18}O$ and $\delta^{13}C$, ostracods	Gasse et al., 1996
3.)	Ngangla Ring Tso	64	31.5	83.1	10.4-8.6 cal ka	n/a	lake level, tufa dating	this study
4.)	Lagkor Tso	9	32.0	84.1	11.1-9.9 cal ka	n/a	lake level, tufa and OSL dating	this study, Lee et al., 2009
5.)	Chabyer Tsaka (Zabuye)	73	31.4	84.1	11.1-9.9 cal ka	n/a	lake level, tufa dating	this study
6.)	Sumxi-Longmu Tso	54	34.6	80.5	10.0-4.4	13.0-present	% $CaCO_3$, terrestrial pollen, diatoms, bulk carbonate $\delta^{18}O$ and $\delta^{13}C$, ostracods	Van Campo and Gasse, 1993
					12.8±1.1-6.4±0.7	n/a	lake level, ^{10}Be exposure dating	Kong et al., 2007
7.)	Nam Tso	123	30.7	90.6	>8.4-5.5 cal ka	8.4-present	terrestrial pollen	Li et al., 2011
					>7.3-5.4 cal ka	7.3-present	grain size, TOC, major elements, bulk OM and n-alkane δD and $\delta^{13}C$	Mugler et al., 2010
8.)	Ahung Tso	n/a	31.6	92.0	10.0-7.5 cal ka	10.0-4.0	% $CaCO_3$, % Dolomite, carbonate $\delta^{18}O$ and $\delta^{13}C$, % TOC, TOC $\delta^{13}C$, C/N ratio	Morrill et al., 2006
9.)	Zigetang Tso	50	32.1	90.9	7.5-4.4 cal ka	10.8-present	terrestrial pollen	Herzschuh et al., 2006
10.)	Naleng Lake	n/a	31.1	99.8	14.8-13.0, 10.8-4.4 cal ka	17.7-present	terrestrial pollen	Kramer et al., 2010
11.)	Hongyuan Peat	n/a	32.8	102.5	10.0-8.5 cal ka	12.0-~1.5	n-alkane δD	Seki et al., 2011
12.)	Kuhai Lake	n/a	35.4	99.2	7.5-6.0 cal ka	>14.8-present	terrestrial pollen	Wischnewski et al., 2011
13.)	Qinghai Lake	n/a	36.9	100.2	7.5-5.0 cal ka	16.0-present	terrestrial pollen, % TOC, TOC $\delta^{13}C$, carbonate mineralogy	Shen et al., 2005

†Record length is only shown for proxy records (mostly cores). Shoreline records do not form a continuous record, and so are not treated.