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Survival of the Qaidam mega-lake system under mid-Pliocene climates and its restoration under future climates

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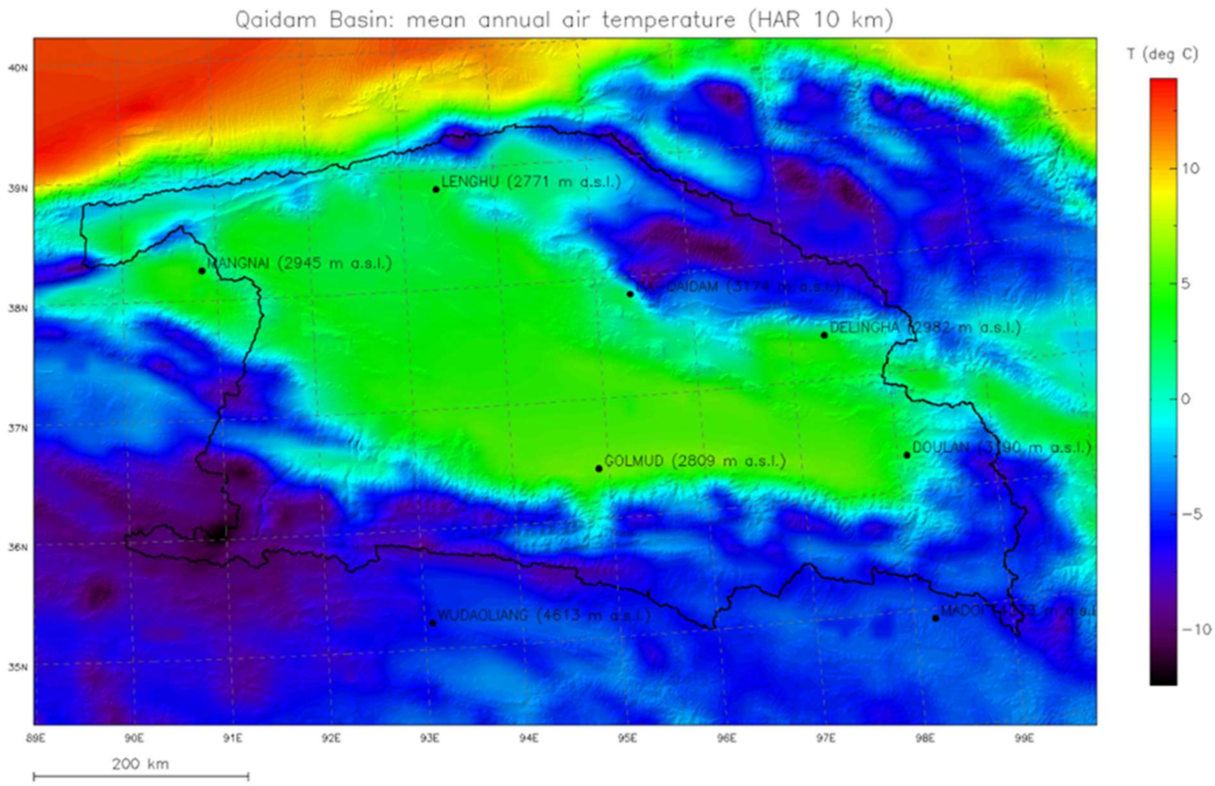

Figure S1: Mean annual air temperature (2 m above ground) during the study period of 14 hydrological years (2001-2014) for the Qaidam Basin (QB) and its surrounding regions derived from the HAR 10 km data set. Black line: boundary of the QB (Lehner and Grill, 2013). Topographic shading is based on DEM data from the SRTM. Black dots indicate the locations of the eight GSOD stations within or nearby the QB.

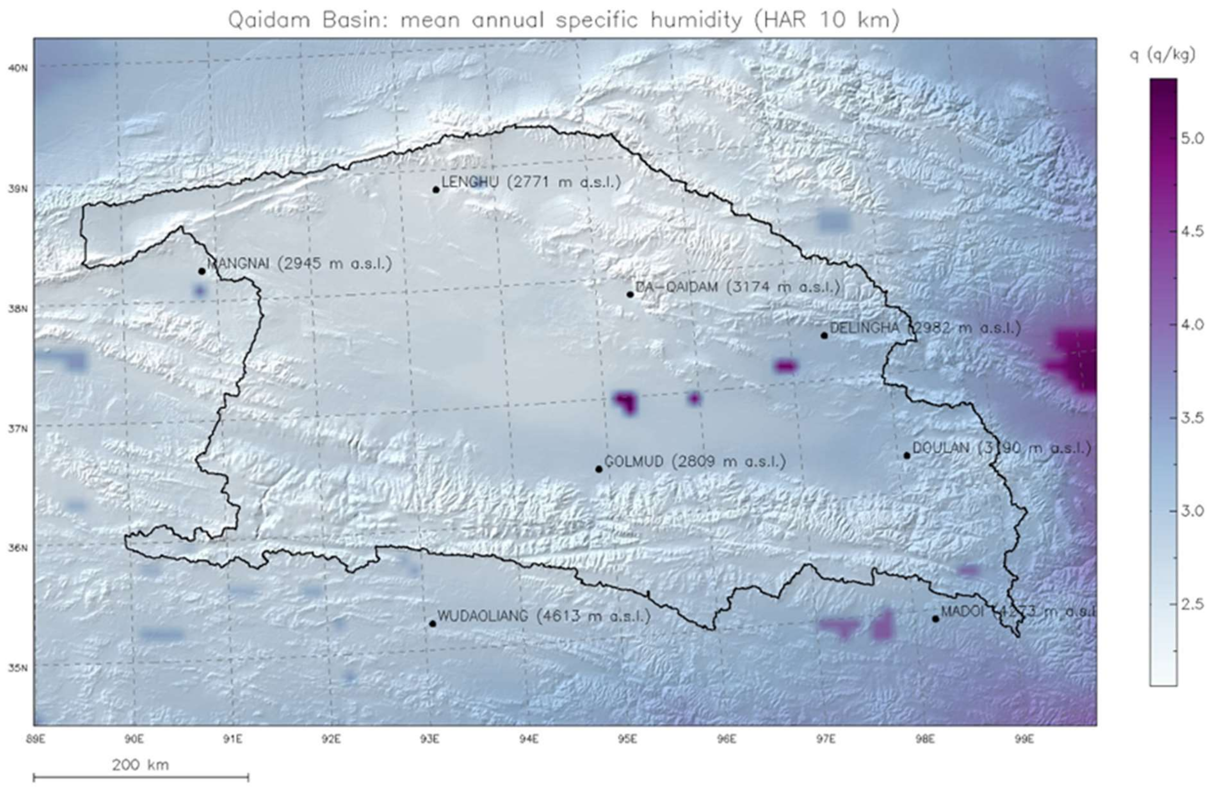

Figure S2: Mean annual specific humidity (2 m above ground) during the study period of 14 hydrological years (2001-2014) for the Qaidam Basin (QB) and its surrounding regions derived from the HAR 10 km data set. Black line: boundary of the QB (Lehner and Grill, 2013). Topographic shading is based on DEM data from the SRTM. Black dots indicate the locations of the eight GSOD stations within or nearby the QB.

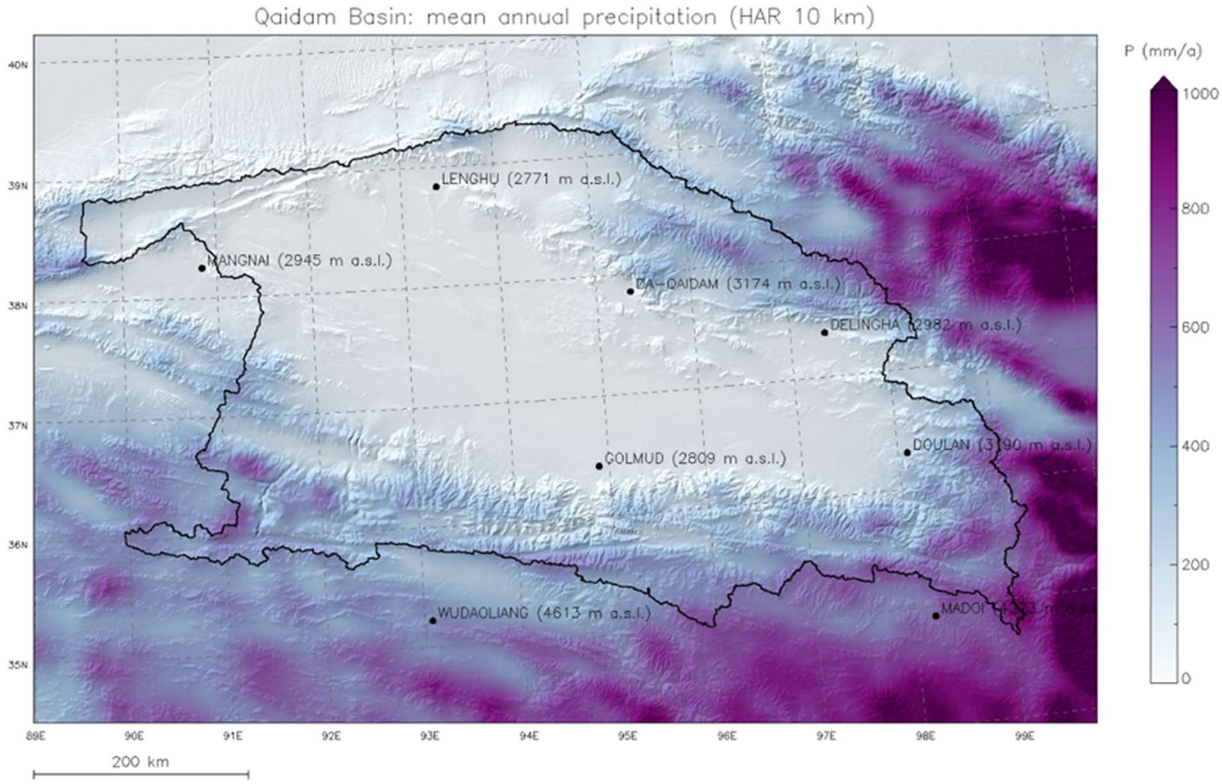

Figure S3: Mean annual precipitation during the study period of 14 hydrological years (2001-2014) for the Qaidam Basin (QB) and its surrounding regions derived from the HAR 10 km data set. Black line: boundary of the QB (Lehner and Grill, 2013). Topographic shading is based on DEM data from the SRTM. Black dots indicate the locations of the eight GSOD stations within or nearby the QB.

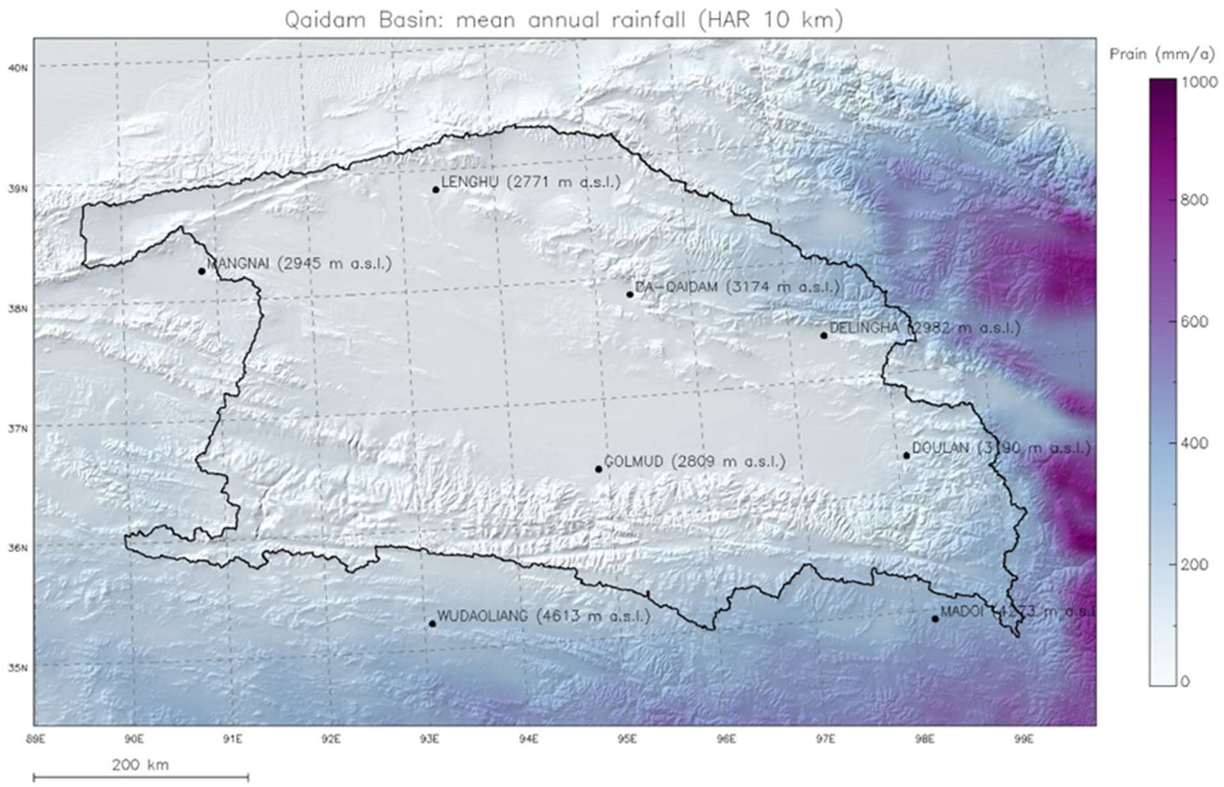

Figure S4: Mean annual rainfall during the study period of 14 hydrological years (2001-2014) for the Qaidam Basin (QB) and its surrounding regions derived from the HAR 10 km data set. Black line: boundary of the QB (Lehner and Grill, 2013). Topographic shading is based on DEM data from the SRTM. Black dots indicate the locations of the eight GSOD stations within or nearby the QB.

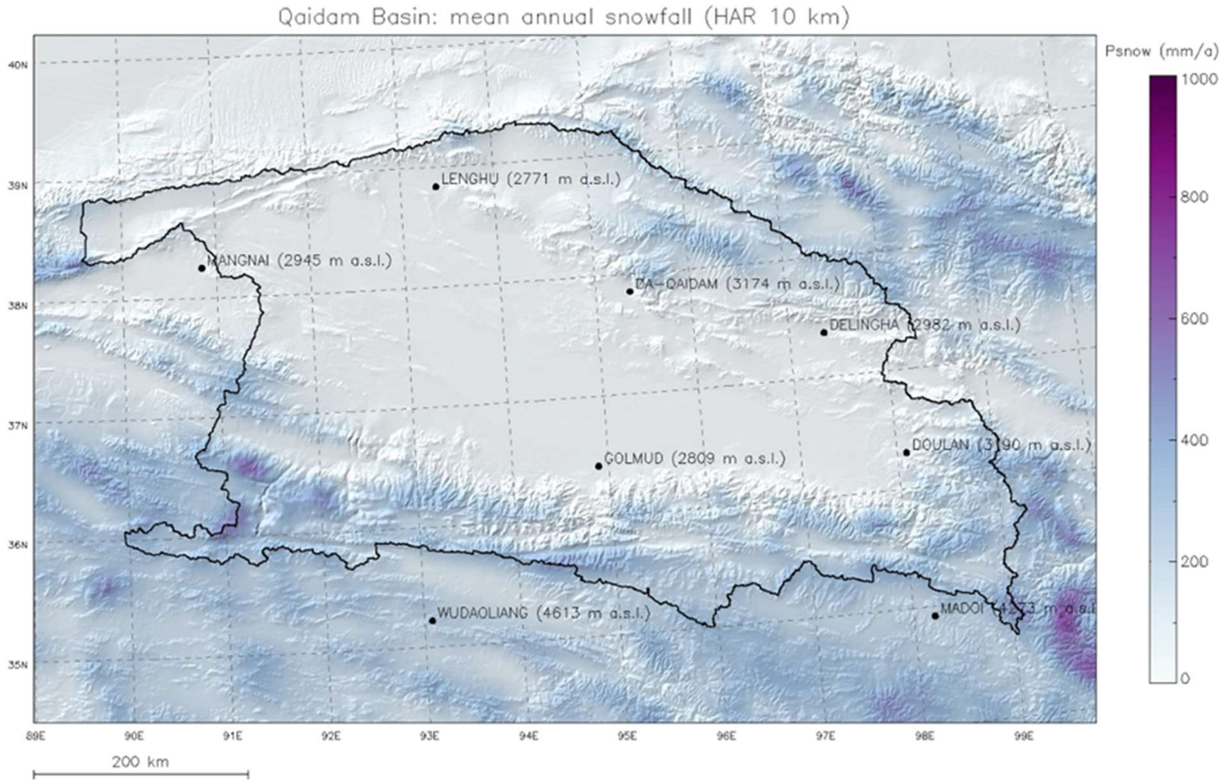

Figure S5: Mean annual snowfall during the study period of 14 hydrological years (2001-2014) for the Qaidam Basin (QB) and its surrounding regions derived from the HAR 10 km data set. Black line: boundary of the QB (Lehner and Grill, 2013). Topographic shading is based on DEM data from the SRTM. Black dots indicate the locations of the eight GSOD stations within or nearby the QB.

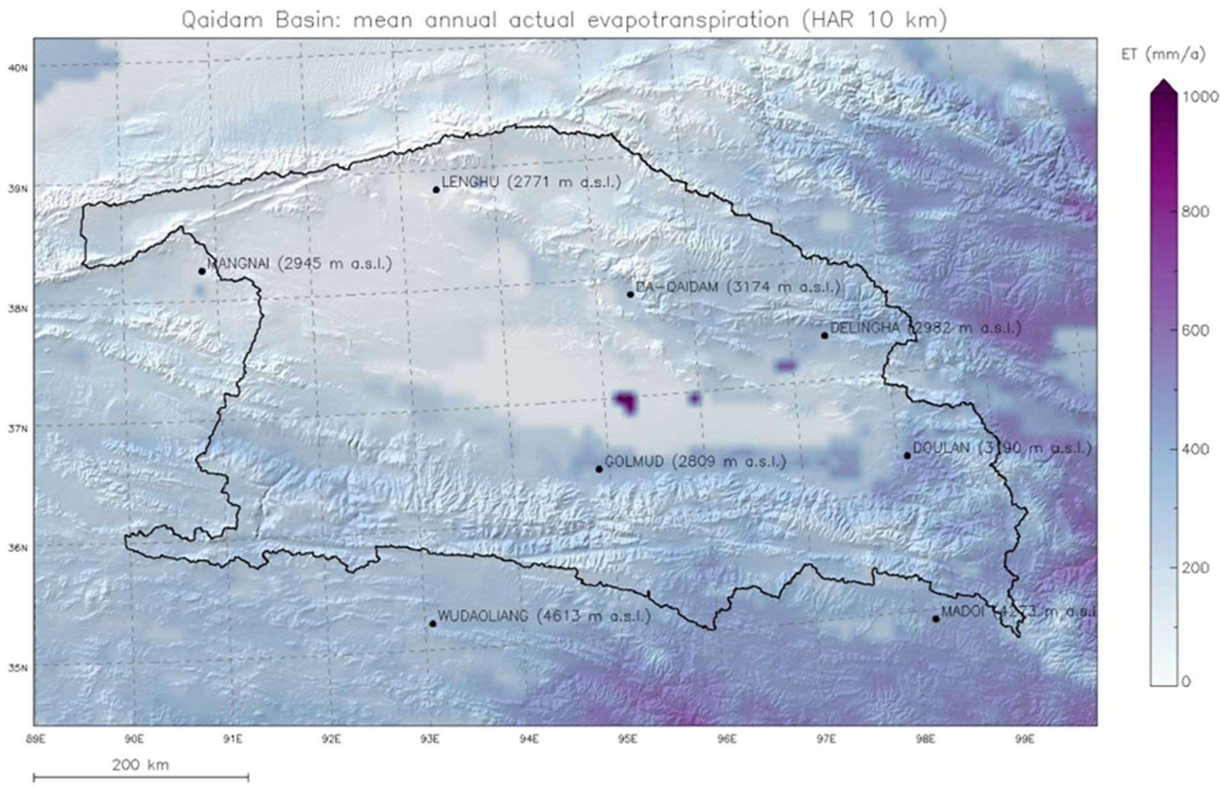

Figure S6: Mean annual actual evapotranspiration during the study period of 14 hydrological years (2001-2014) for the Qaidam Basin (QB) and its surrounding regions derived from the HAR 10 km data set. Black line: boundary of the QB (Lehner and Grill, 2013). Topographic shading is based on DEM data from the SRTM. Black dots indicate the locations of the eight GSOD stations within or nearby the QB.

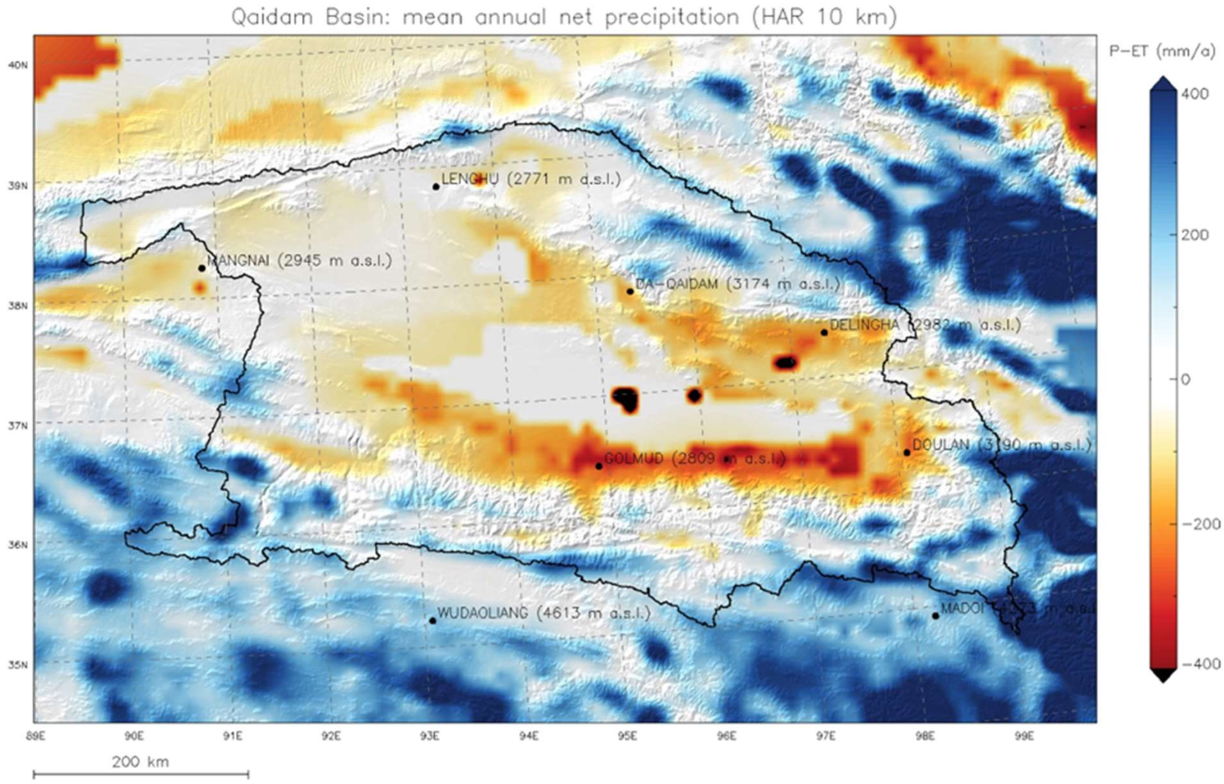

Figure S7: Mean annual net precipitation, i.e., precipitation *P* minus actual evapotranspiration *ET*, during the study period of 14 hydrological years (2001-2014) for the Qaidam Basin (QB) and its surrounding regions derived from the HAR 10 km data set. Black line: boundary of the QB (Lehner and Grill, 2013). Topographic shading is based on DEM data from the SRTM. Black dots indicate the locations of the eight GSOD stations within or nearby the QB.

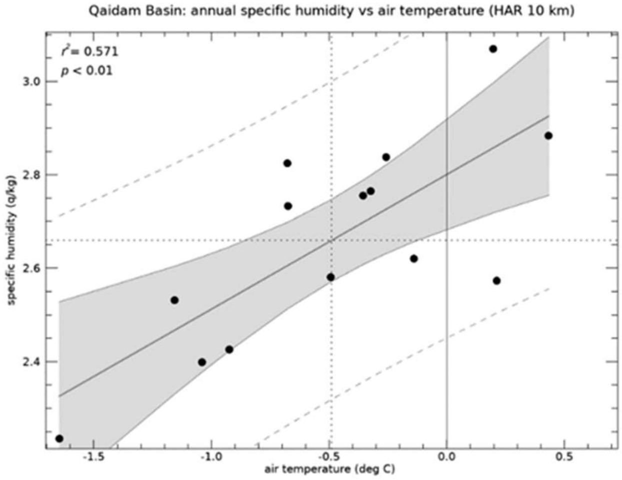

Figure S8: Specific humidity versus air temperature in the Qaidam Basin (QB) during the hydrological years 2001 to 2014 derived from the HAR 10 km data set. Dotted lines: mean annual values; solid lines: regression lines; light grey shades: confidence interval; dashed lines: prediction interval.

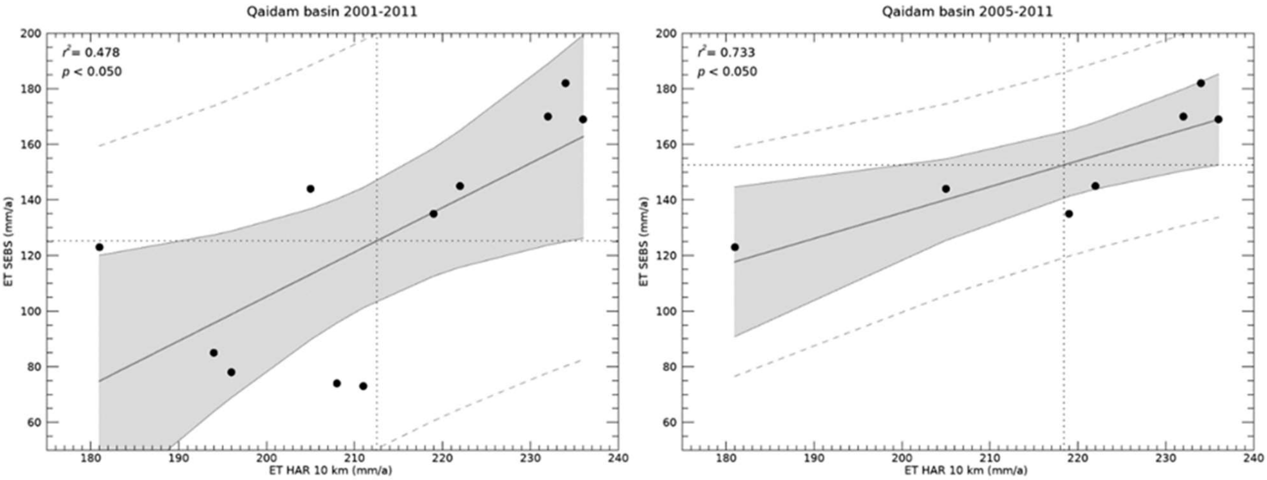

Figure S9: Annual actual evapotranspiration *ET* determined by the SEBS-based study of Jin et al. (2013) versus *ET* of the HAR 10 km data set in the Qaidam Basin (QB) for the calendar years 2001-2011 (left panel) and 2005-2011 (right panel). Dotted lines: mean annual values; solid lines: regression lines; light grey shades: confidence intervals; dashed lines: prediction intervals.

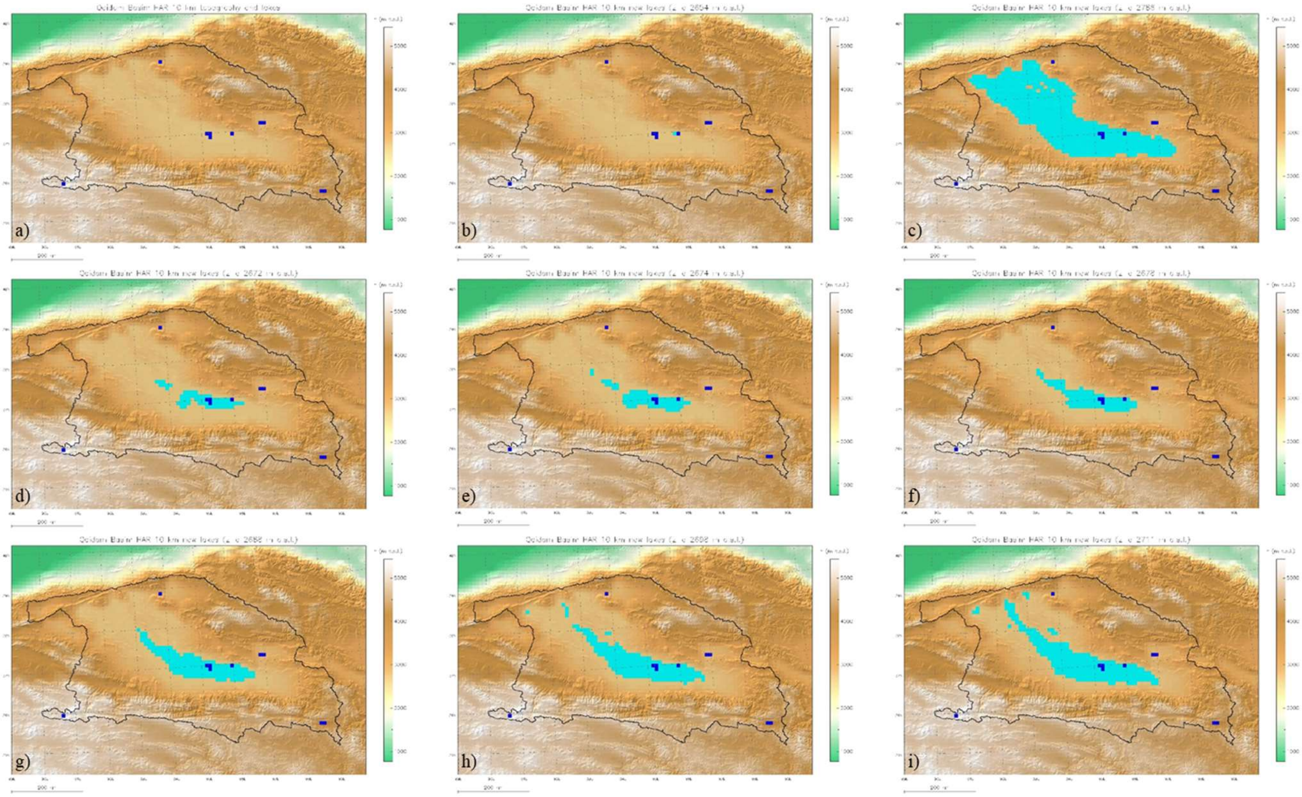

Figure S10: Panel a): present-day lake extent in the Qaidam Basin (QB) as represented in the HAR 10 km data set. Panels b) to i): illustrations of lake extents for different projections of equilibrium lake states using the present-day model topography of the HAR 10 km data set for accumulation of net precipitation in the QB and subsequent runoff originating from land in areas below equilibrium lake levels (marked in cyan). Equilibrium lake levels (cf. Table 3): panel b) 2654 m a.s.l. (one metre above lowest present-day level); panel c) maximum extent of the mega-lake system of approx. 59 000 km^2 as reported by Chen and Bowler (1986); 2786 m a.s.l.; panel d) 2672 m a.s.l. (dP_{QB} = 50 mm/a; ET_{lake} = 1000 mm/a); panel e) 2674 m a.s.l. (dP_{QB} = 50 mm/a; ET_{lake} = 800 mm/a); panel f) 2678 m a.sl. (dP_{QB} = 50 mm/a; ET_{lake} = 600 mm/a); panel g) 2688 m a.sl. (dP_{QB} = 100 mm/a; ET_{lake} = 1000 mm/a); panel h) 2698 m a.sl. (dP_{QB} = 100 mm/a; ET_{lake} = 800 mm/a); panel i) 2711 m a.sl. (dP_{QB} = 100 mm/a; ET_{lake} = 600 mm/a). Black line: boundary of the QB (Lehner and Grill, 2013). Blue: present-day lake extent (1000 km^2) as represented in the HAR 10 km data set. Topographic shading is based on DEM data from the SRTM.

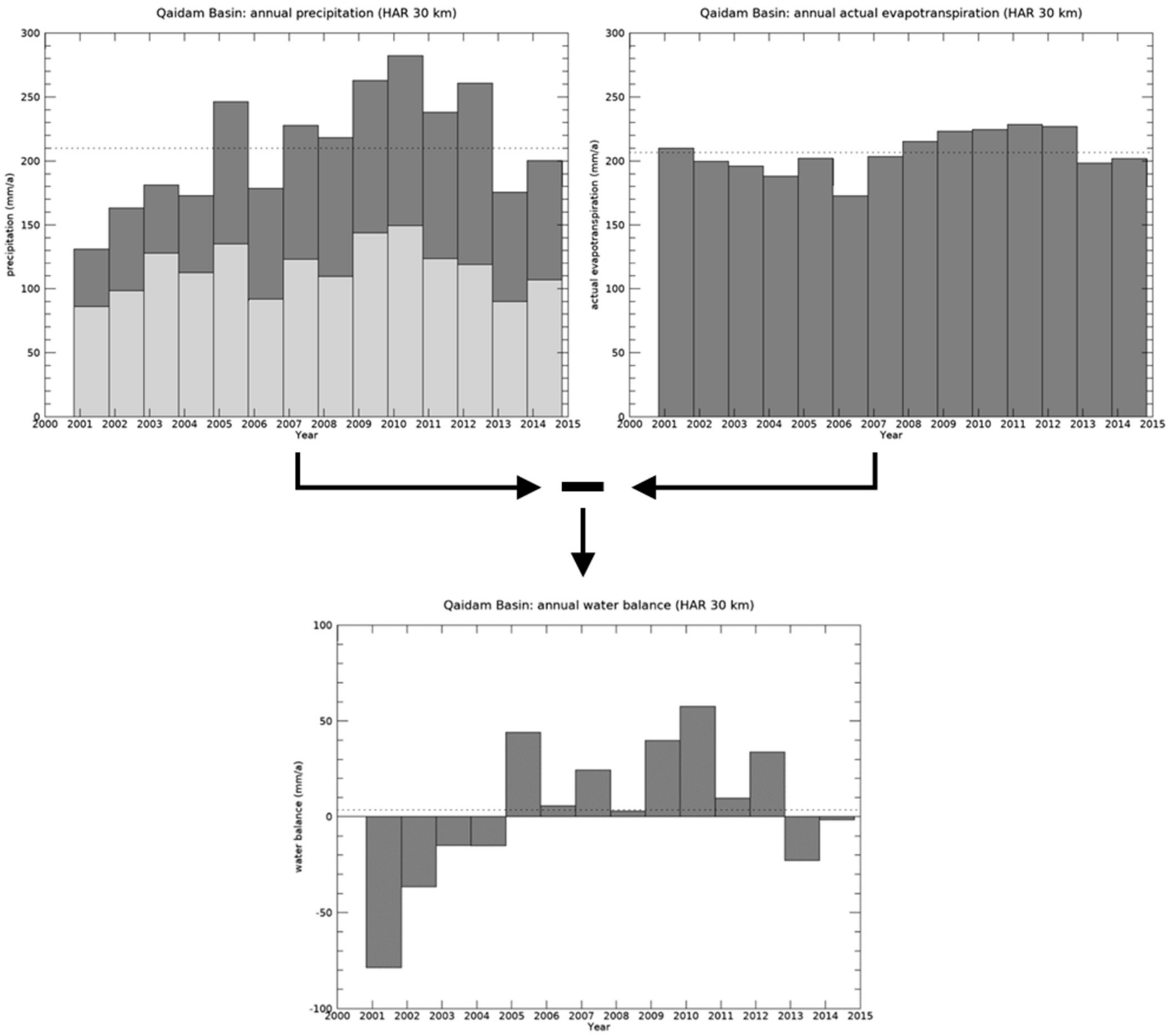

Figure S11: Annual precipitation (upper left panel), actual evapotranspiration (upper right panel), and water balance (lower panel) in the Qaidam Basin (QB) during the hydrological years 2001 to 2014 as in Fig. 2 but derived from the HAR 30 km data set. Upper left panel: light grey bars: annual snowfall; dark grey bars: annual rainfall. Dotted lines: mean annual values.

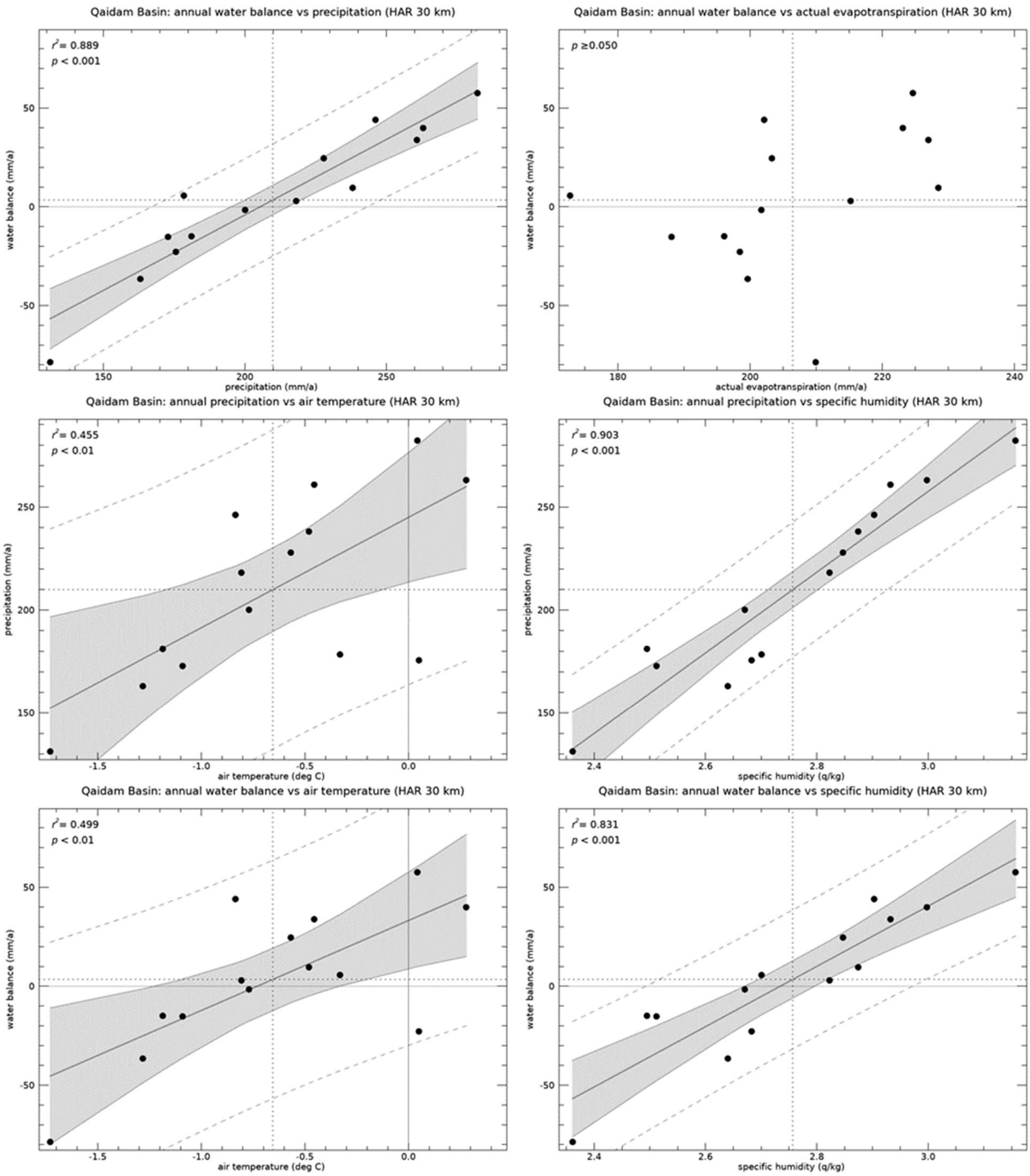

Figure S12: Water balance versus precipitation (upper left panel) and actual evapotranspiration (upper right panel); precipitation versus air temperature (middle left panel) and specific humidity (middle right panel); water balance versus air temperature (lower left panel) and specific humidity (lower right panel) in the Qaidam Basin (QB) during the hydrological years 2001 to 2014 as in Fig. 4 but derived from the HAR 30 km data set. Dotted lines: mean annual values; solid lines: regression lines; light grey shades: confidence intervals; dashed lines: prediction intervals.

2 Supplementary Tables

Table S2: Monthly and annual air temperature *T* (in deg C) in the Qaidam Basin (QB) during the 14 hydrological years (2001-2014) covered by the HAR 10 km data set.

T	10	11	12	1	2	3	4	5	6	7	8	9	**year**
2001	-2.0	-10.3	-14.2	-16.1	-11.5	-7.7	-1.8	3.5	9.4	13.3	10.6	6.5	**-1.6**
2002	-1.5	-8.3	-14.5	-16.7	-10.8	-6.6	1.0	4.1	9.9	12.4	11.6	5.1	**-1.2**
2003	-3.1	-9.5	-12.3	-13.2	-10.2	-5.9	0.2	3.9	9.2	11.2	10.6	6.1	**-1.0**
2004	-1.2	-7.4	-12.7	-14.9	-11.6	-4.3	1.4	4.1	8.4	11.2	10.3	5.3	**-0.9**
2005	-2.0	-10.6	-11.8	-13.1	-10.4	-4.8	-0.5	5.1	9.6	11.6	10.9	7.3	**-0.7**
2006	-0.9	-8.7	-13.4	-11.5	-8.5	-6.6	-0.7	5.1	9.7	13.0	12.9	7.7	**-0.1**
2007	0.8	-7.3	-13.7	-16.2	-10.0	-5.8	0.9	7.0	9.4	11.5	12.0	6.6	**-0.4**
2008	-0.6	-7.2	-11.7	-14.8	-14.9	-5.4	0.1	7.1	10.0	11.7	9.8	7.2	**-0.7**
2009	0.3	-7.3	-11.0	-12.8	-8.4	-5.0	2.6	5.3	10.2	12.1	10.7	8.0	**0.4**
2010	-0.6	-8.2	-12.6	-11.5	-8.9	-5.3	-0.8	5.4	9.8	13.9	12.8	7.7	**0.2**
2011	-0.2	-8.1	-14.3	-16.5	-8.8	-7.7	0.8	6.4	10.7	12.9	12.8	7.7	**-0.3**
2012	0.9	-5.6	-12.3	-17.9	-11.9	-6.8	0.1	6.4	10.7	12.7	12.6	7.6	**-0.3**
2013	-1.0	-9.1	-13.7	-15.2	-9.6	-2.5	1.3	6.3	11.5	12.9	13.8	7.4	**0.2**
2014	0.8	-10.3	-15.2	-14.1	-11.3	-4.4	-0.1	5.0	10.2	13.4	11.6	7.9	**-0.5**
mean	**-0.7**	**-8.4**	**-13.1**	**-14.6**	**-10.5**	**-5.6**	**0.3**	**5.3**	**9.9**	**12.4**	**11.6**	**7.0**	**-0.5**

Table S2: Monthly and annual specific humidity *q* (in g/kg) in the Qaidam Basin (QB) during the 14 hydrological years (2001-2014) covered by the HAR 10 km data set.

q	10	11	12	1	2	3	4	5	6	7	8	9	**year**
2001	1.9	1.2	1.0	0.8	0.9	1.0	1.8	2.3	3.1	4.2	4.7	3.8	**2.2**
2002	1.7	1.3	1.0	0.9	1.1	1.4	2.2	2.7	4.0	5.5	4.4	4.0	**2.5**
2003	2.0	1.4	1.3	1.1	1.4	1.7	2.4	2.5	3.5	4.0	4.3	3.1	**2.4**
2004	1.8	1.6	1.1	1.1	1.3	1.7	1.9	2.7	3.3	4.5	5.0	2.9	**2.4**
2005	2.0	1.4	1.3	1.1	1.2	1.9	1.9	2.8	4.2	6.2	5.7	4.0	**2.8**
2006	2.0	1.2	0.8	1.1	1.5	1.1	1.7	2.4	4.3	6.4	5.1	3.5	**2.6**
2007	2.2	1.5	1.0	0.7	1.2	1.7	2.0	2.5	4.4	5.5	5.9	4.3	**2.8**
2008	2.7	1.3	1.0	1.0	1.1	1.5	1.8	3.0	4.2	6.1	4.6	4.5	**2.7**
2009	2.6	1.6	1.2	1.1	1.3	1.5	2.0	2.9	4.1	6.1	4.8	5.3	**2.9**
2010	2.4	1.4	1.1	1.1	1.4	1.7	2.0	3.1	5.6	7.1	5.1	4.7	**3.1**
2011	2.6	1.3	0.9	0.7	1.3	1.3	2.0	3.2	4.8	5.4	5.6	4.0	**2.8**
2012	2.3	1.7	0.9	0.8	1.2	1.5	1.7	3.4	5.0	6.5	6.0	3.1	**2.8**
2013	1.9	1.1	0.9	0.9	1.2	1.2	1.6	3.2	4.5	5.9	5.2	3.3	**2.6**
2014	2.0	1.2	0.9	0.8	1.1	1.5	2.0	2.1	4.6	5.4	5.0	4.2	**2.6**
mean	**2.2**	**1.4**	**1.0**	**0.9**	**1.2**	**1.5**	**1.9**	**2.8**	**4.3**	**5.6**	**5.1**	**3.9**	**2.7**

Table S3: Monthly and annual precipitation P (in millimetres per month or millimetres per year) in the Qaidam Basin (QB) during the 14 hydrological years (2001-2014) covered by the HAR 10 km data set.

$\boldsymbol{P}$	10	11	12	1	2	3	4	5	6	7	8	9	**year**
2001	5	4	6	3	3	3	19	16	17	11	20	15	**122**
2002	2	1	6	3	3	10	16	25	34	25	12	22	**160**
2003	5	3	6	4	8	17	28	23	19	21	26	10	**171**
2004	3	5	5	8	10	11	12	29	24	24	24	8	**163**
2005	6	4	8	3	7	13	9	27	29	55	39	26	**229**
2006	5	2	1	3	12	4	16	16	37	39	23	12	**170**
2007	8	3	2	1	5	14	14	20	59	35	28	33	**222**
2008	7	2	1	6	6	7	13	24	26	60	25	35	**212**
2009	13	5	6	6	9	14	11	44	20	57	33	38	**256**
2010	12	5	4	5	7	21	14	39	77	42	18	26	**270**
2011	11	1	3	3	6	12	14	35	49	29	35	22	**221**
2012	7	5	1	3	6	10	10	44	46	60	40	14	**246**
2013	12	4	4	3	7	2	7	30	24	41	18	23	**174**
2014	5	3	2	1	5	9	19	14	41	31	27	30	**188**
mean	**7**	**3**	**4**	**4**	**7**	**11**	**15**	**28**	**36**	**38**	**26**	**23**	**200**

Table S4: Monthly and annual rainfall P_{rain} (in millimetres per month or millimetres per year) in the Qaidam Basin (QB) during the 14 hydrological years (2001-2014) covered by the HAR 10 km data set.

$\boldsymbol{P}_{rain}$	10	11	12	1	2	3	4	5	6	7	8	9	**year**
2001	1	0	0	0	0	1	3	3	7	10	13	8	**45**
2002	0	0	0	0	0	0	4	8	19	19	9	10	**70**
2003	0	0	0	0	0	1	7	5	8	12	15	3	**52**
2004	0	0	0	0	0	1	3	7	14	16	18	3	**62**
2005	0	0	0	0	1	1	2	8	15	42	28	12	**110**
2006	0	0	0	0	0	0	5	5	19	36	16	6	**87**
2007	2	1	0	0	0	1	5	5	31	26	24	16	**110**
2008	1	0	0	0	0	1	3	10	16	46	15	19	**112**
2009	3	0	0	0	0	1	3	13	11	44	23	27	**126**
2010	1	0	0	0	1	1	2	14	54	36	14	17	**141**
2011	1	0	0	0	1	1	3	10	33	22	30	12	**113**
2012	2	1	0	0	0	0	2	17	28	51	35	5	**142**
2013	2	0	0	0	0	1	2	11	18	33	16	9	**93**
2014	1	0	0	0	0	1	4	4	24	26	20	14	**95**
mean	**1**	**0**	**0**	**0**	**1**	**1**	**4**	**9**	**21**	**30**	**19**	**12**	**97**

Table S5: Monthly and annual snowfall P_{snow} (in millimetres per month or millimetres per year) in the Qaidam Basin (QB) during the 14 hydrological years (2001-2014) covered by the HAR 10 km data set.

P_{snow}	10	11	12	1	2	3	4	5	6	7	8	9	year
2001	4	4	6	3	3	2	16	13	10	1	7	7	**77**
2002	2	1	6	3	3	10	12	17	15	6	3	12	**90**
2003	5	3	6	4	8	16	21	18	11	9	11	7	**119**
2004	3	5	5	8	10	10	9	22	10	8	6	5	**101**
2005	6	4	8	3	6	12	7	19	14	13	11	14	**119**
2006	5	2	1	3	12	4	11	11	18	3	7	6	**83**
2007	6	2	2	1	5	13	9	15	28	9	4	17	**112**
2008	6	2	1	6	6	6	10	14	10	14	10	16	**100**
2009	10	5	6	6	9	13	8	31	9	13	10	11	**130**
2010	11	5	4	5	6	20	12	25	23	6	4	9	**129**
2011	10	1	3	3	5	11	11	25	16	7	5	10	**108**
2012	5	4	1	3	6	10	8	27	18	9	5	9	**104**
2013	10	4	4	3	7	1	5	19	6	8	2	14	**81**
2014	4	3	2	1	5	8	15	10	17	5	7	16	**93**
mean	**6**	**3**	**4**	**4**	**6**	**10**	**11**	**19**	**15**	**8**	**7**	**11**	**103**

Table S6: Monthly and annual actual evapotranspiration ET (in millimetres per month or millimetres per year) in the Qaidam Basin (QB) during the 14 hydrological years (2001-2014) covered by the HAR 10 km data set.

ET	10	11	12	1	2	3	4	5	6	7	8	9	year
2001	13	7	5	5	8	16	22	30	28	32	31	20	**216**
2002	10	5	4	4	8	14	18	26	33	34	27	20	**204**
2003	12	7	5	5	9	17	21	26	25	28	27	18	**200**
2004	10	6	4	5	8	14	17	25	25	30	32	17	**193**
2005	10	6	5	6	8	14	20	23	27	34	31	21	**208**
2006	11	6	4	6	7	10	13	19	27	34	25	17	**179**
2007	11	7	5	4	8	16	15	20	31	38	32	24	**210**
2008	17	8	6	5	7	13	18	22	30	35	37	23	**222**
2009	17	9	6	6	9	16	18	27	29	37	32	26	**233**
2010	16	10	6	7	9	17	20	23	36	39	30	20	**234**
2011	18	10	7	6	11	16	18	28	33	34	34	23	**238**
2012	16	10	5	4	9	17	20	32	32	34	36	21	**238**
2013	13	8	5	5	9	11	12	29	29	35	30	22	**209**
2014	14	8	4	6	8	13	24	21	24	34	31	23	**212**
mean	**13**	**8**	**5**	**5**	**9**	**15**	**18**	**25**	**29**	**34**	**31**	**21**	**214**

Table S7: Monthly and annual water balance Δ*S* (in millimetres per month or millimetres per year) in the Qaidam Basin (QB) during the 14 hydrological years (2001-2014) covered by the HAR 10 km data set.

Δ*S*	10	11	12	1	2	3	4	5	6	7	8	9	**year**
2001	-8	-3	1	-2	-5	-13	-3	-13	-11	-21	-11	-5	**-94**
2002	-8	-4	2	-1	-4	-4	-2	-2	2	-9	-15	1	**-44**
2003	-6	-4	1	-1	-1	0	7	-2	-6	-7	-1	-8	**-29**
2004	-7	-1	1	3	2	-3	-5	3	-1	-6	-8	-9	**-30**
2005	-4	-2	3	-3	-2	-1	-11	4	2	21	8	5	**21**
2006	-6	-4	-2	-2	5	-6	3	-3	10	5	-3	-5	**-10**
2007	-3	-4	-3	-4	-3	-2	-2	0	29	-2	-4	10	**11**
2008	-10	-7	-4	1	-1	-7	-5	2	-5	25	-12	12	**-10**
2009	-5	-4	-1	0	0	-1	-7	17	-9	20	1	12	**24**
2010	-4	-5	-3	-2	-2	4	-6	16	42	3	-13	6	**36**
2011	-7	-9	-3	-3	-5	-4	-4	6	16	-5	1	-1	**-17**
2012	-9	-5	-4	-1	-3	-7	-10	12	14	26	3	-7	**8**
2013	-1	-4	-2	-2	-2	-9	-5	1	-5	6	-12	1	**-35**
2014	-9	-6	-3	-4	-3	-4	-5	-6	17	-3	-4	7	**-24**
mean	**-6**	**-4**	**-1**	**-2**	**-2**	**-4**	**-4**	**2**	**7**	**4**	**-5**	**1**	**-14**

Table S8: Annual actual evapotranspiration *ET* in the Qaidam Basin (QB) during the calendar years 2001 to 2011 covered by both the HAR 10 km data set and the SEBS data as published in Jin et al. (2013).

***ET* (mm/a)**	HAR 10 km	SEBS	Diff.
2001	211	73	138
2002	208	74	134
2003	196	78	118
2004	194	85	110
2005	205	144	61
2006	181	123	58
2007	219	135	84
2008	222	145	77
2009	232	170	62
2010	236	169	67
2011	234	182	52
2001-2011	213	125	87
2001-2004	202	77	125
2005-2011	**218**	**153**	**66**

Table S9: Mean monthly and annual air temperature T (in deg C), specific humidity q (in g/kg), precipitation P (in millimetres per month or millimetres per year), rainfall P_{rain} (in millimetres per month or millimetres per year), snowfall P_{snow} (in millimetres per month or millimetres per year), actual evapotranspiration ET (in millimetres per month or millimetres per year), and water balance $\Delta S = P - ET$ (in millimetres per month or millimetres per year) in the Qaidam Basin (QB) as in Table 1 but derived from the HAR 30 km data set; sigma: standard deviations of annual values for each quantity during the hydrological years 2001 to 2014.

month	10	11	12	1	2	3	4	5	6	7	8	9	**year**	sigma
T	-0.9	-8.6	-13.2	-14.8	-10.6	-5.9	0.1	5.2	9.8	12.3	11.5	6.7	**-0.7**	0.6
q	2.3	1.4	1.1	1.0	1.3	1.5	2.0	2.9	4.4	5.8	5.3	4.0	**2.8**	0.2
P	8	4	4	4	7	11	15	29	39	39	28	23	**210**	45
P_{rain}	1	1	0	0	0	1	4	8	22	29	19	11	**95**	30
P_{snow}	7	3	4	4	7	10	11	21	17	10	9	12	**115**	20
ET	13	8	5	6	9	14	18	24	28	32	29	20	**206**	16
ΔS	-5	-4	-1	-2	-1	-4	-3	5	11	7	-2	3	**3**	36

3 R Source code of the semi-empirical model for estimation of water-balance components in the Qaidam Basin

```
#*****************************************************************************
# Semi-empirical model for computation of water balance components in the
# Qaidam Basin (QB) for different projections of lake extent (A.lake),
# precipitation change in entire QB (dP.QB) with respect to present-day
# precipitation (HAR 10 km), and mean rate of lake evaporation (ET.lake).
#
# Regard: increased lake extent with high volumes of total lake evaporation
# would lead to an additional increase in specific humidity, and thus enhance
# local recycling of water. This feedback process is not considered in the
# computations.
#
# The R function QB.dS provides estimates used in the 2nd revison of the
# manuscript "Scherer, D.: Survival of the Qaidam Mega-Lake System under
# Mid-Pliocene Climates and its Restoration under Future Climates",
# submitted to HESS in June 2020.
#
# All quantitities are expressed as mean annual values. The following
# abbreviations are used in the R code for naming of variables:
#
# Quantities:
#   A:     area (extent) (km^2)
#   P:     precipitation (mm/a)
#   ET:    actual evapotranspiration (mm/a)
#   P.net: net precipitation (P - ET) (mm/a)
#   R:     runoff from land areas into lakes (mm/a)
#   dS:    change in water storage (water balance) (mm/a)
#
# Subscripts:
#   QB:    Qaidam Basin (entire drainage basin)
#   PD:    present-day (as represented in the HAR 10 km data set)
#   nml:   no mega-lake projection (present-day lake extent as in HAR 10 km)
#   land:  land area of QB
#   lake:  lake area of QB
#   low:   low-altitude areas in the QB (z < 2.8 km a.s.l.)
#   gw:    groundwater
#
# Results of the computations are returned in a R data frame.
#
# Author:      Dieter Scherer, Technische Universitaet Berlin, Germany
# Last update: 18.06.2020
#
#*****************************************************************************

QB.dS <- function(A.lake, dP.QB, ET.lake) {

  #***********************************************************
  # Quantities regarded not to change significantly over time
  #***********************************************************

  A.QB <- 254000 # km^2; total area (A) of entire QB

  # Sensitivities from HAR 10 km analysis

  dET.dP.QB <- 0.2748 # sensitivity of ET to changes in P averaged over entire QB
  ddS.dP.QB <- 0.7252 # sensitivity of dS to changes in P averaged over entire QB

  #***********************************************
  # Quantities for present day (PD) from HAR 10 km
  #***********************************************

  A.lake.PD <- 1000 # km^2; present-day lake area (no mega-lake system)

  P.QB.PD   <-  200 # mm/a; P averaged over entire QB
  P.low.PD  <-   40 # mm/a; P averaged over lower altitudes (z < 2.8 km a.s.l.)

  ET.QB.PD  <-  214 # mm/a; ET averaged over entire QB

  dS.QB.PD  <- P.QB.PD - ET.QB.PD # mm/a; dS (= P.net) averaged over entire QB

  #******************
  # Projected changes
  #******************

  A.land <- A.QB - A.lake # km^2; land area of QB

  # Changes in P are assumed to uniformly take place at all altitudes

  P.QB     <- P.QB.PD  + dP.QB # mm/a; P averaged over entire QB
  P.low    <- P.low.PD + dP.QB # mm/a; P averaged over lower altitudes (< 2.8 km a.s.l.)
  P.lake   <- P.low            # mm/a; mega-lake system forms at lower altitudes

  P.land   <- (P.QB*A.QB-P.lake*A.lake)/A.land # mm/a; P averaged over land area
```

```
  # Changes for projection for QB with lake extent for PD (no mega-lake system)

  P.QB.nml  <- P.QB                       # mm/a; P  averaged over entire QB
  dS.QB.nml <- dS.QB.PD + ddS.dP.QB*dP.QB # mm/a; dS averaged over entire QB
  ET.QB.nml <- P.QB.nml - dS.QB.nml       # mm/a; ET averaged over entire QB
 #ET.QB.nml <- ET.QB.PD + dET.dP.QB*dP.QB # mm/a; ET averaged over entire QB

  # Changes in ET, net P (P-ET) and dS

  ET.land <- (ET.QB.nml*A.QB-ET.lake*A.lake.PD)/A.land # mm/a; ET averaged over land area
  ET.QB   <- (ET.land*A.land+ET.lake*A.lake)/A.QB      # mm/a; ET averaged over entire QB

  P.net.lake <- P.lake - ET.lake        # mm/a; P.net averaged over mega-lake system
  P.net.land <- P.land - ET.land        # mm/a; P.net averaged over land area
  P.net.QB   <- P.QB   - ET.QB          # mm/a; P.net averaged over entire QB

  dS.QB      <- P.net.QB                # mm/a; dS (= P.net) averaged over entire QB

  # Estimate change in (mega-)lake system

  if (P.net.land >= 0) {
    R.gw    <- 0                        # mm/a; no groundwater recharge (aquifers are considered to be filled)
    R.lake  <- P.net.land*A.land/A.lake # mm/a; runoff from land area into lakes
  } else {
    R.gw    <- P.net.land               # mm/a; all water losses are due to groundwater discharge
    R.lake  <- 0                        # mm/a; no runoff from land area into lakes
  }

  dS.lake <- P.net.lake + R.lake # mm/a; change in lake water storage

  # Return results as data frame

  results <- data.frame(A.QB, A.land, A.lake, dP.QB, P.QB, P.land, P.lake,
                        ET.QB, ET.land, ET.lake, P.net.land, P.net.lake,
                        dS.QB, R.lake, dS.lake)

  return(results)
}

#**************************************
# Values used in the Qaidam Basin study
#**************************************

# Projections for changes in precipitation

dP.QB.1 <- 100 # mm/a; upper estimate from HAR analysis: projection 1
dP.QB.2 <-  50 # mm/a; lower estimate from HAR analysis: projection 2

# Projections for mean rates of lake evaporation

ET.lake.a <-  600 # mm/a; lower estimate from HAR analysis (mean ET.lake in HAR: 650 mm/a): projection a
ET.lake.b <-  800 # mm/a; medium estimate from literature and HAR analysis: projection b
ET.lake.c <- 1000 # mm/a; upper estimate from HAR analysis: projection c

# Approximate equilibrium requirements for changes in precipitation and mean rates of lake evaporation

dP.QB.mle.a   <- 210 # mm/a; required for sustaining maximum extent of mega-lake system (for ET.lake.a)
dP.QB.mle.b   <- 270 # mm/a; required for sustaining maximum extent of mega-lake system (for ET.lake.b)
dP.QB.mle.c   <- 330 # mm/a; required for sustaining maximum extent of mega-lake system (for ET.lake.c)

dP.QB.HAR     <- 19.3 # mm/a; required for sustaining HAR lake extent (identical for ET.lake.a, ET.lake.b, and ET.lake.c)

ET.lake.mle.1 <- 260 # mm/a; required for sustaining maximum extent of mega-lake system (for dP.QB.1)
ET.lake.mle.2 <- 110 # mm/a; required for sustaining maximum extent of mega-lake system (for dP.QB.2)

# Lake extent either taken from HAR data and literature, or computed as equilibrium values by the semi-empirical model

A.lake.mle <- 59000 # km^2; maximum extent of mega-lake system from literature         (HAR10: z <= 2786 m, A = 59200 km^2)
A.lake.1a  <- 25773 # km^2; approximate sustainable mega-lake extent for projection 1a (HAR10: z <= 2711 m, A = 25900 km^2)
A.lake.1b  <- 19580 # km^2; approximate sustainable mega-lake extent for projection 1b (HAR10: z <= 2698 m, A = 19700 km^2)
A.lake.1c  <- 15864 # km^2; approximate sustainable mega-lake extent for projection 1c (HAR10: z <= 2688 m, A = 15800 km^2)
A.lake.2a  <- 10423 # km^2; approximate sustainable mega-lake extent for projection 2a (HAR10: z <= 2678 m, A = 10800 km^2)
A.lake.2b  <-  8067 # km^2; approximate sustainable mega-lake extent for projection 2b (HAR10: z <= 2674 m, A =  8500 km^2)
A.lake.2c  <-  6654 # km^2; approximate sustainable mega-lake extent for projection 2c (HAR10: z <= 2672 m, A =  6800 km^2)
A.lake.PD  <-  1046 # km^2; present-day lake extent from literature                    (HAR10: z <= 2654 m, A =  1100 km^2)
A.lake.HAR <-  1000 # km^2; present-day lake extent as in HAR 10 km                    (HAR10: z <= 2653 m, A =  1000 km^2)

#*******************************************************
# Example computation (as template for own computations)
#*******************************************************

results <- QB.dS(A.lake=A.lake.1a, dP.QB=dP.QB.1, ET.lake=ET.lake.a)
```