



Supplement of

Isotopic variations in surface waters and groundwaters of an extremely arid basin and their responses to climate change

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| Watershed | Water type | | $\delta^{18}\text{O}$ | δD | d-excess | $\delta^{18}\text{O}$ | δD | d-excess | ^3H | Source |
|---------------|----------------------|--------|-----------------------|------------------|----------|-----------------------|------------------|----------|--------------|--------|
| | | | (‰) | (‰) | (‰) | (‰) | (‰) | (‰) | (‰) | |
| | | | Wet season | | | Dry season | | | | |
| Golmud | Surface water | Mean | 1.24 | 3.58 | 7.50 | 0.47 | 3.42 | 1.99 | 4.50 | |
| | | SD | | | | | | | | |
| | Confined groundwater | Mean | -7.54 | -53.5 | 6.80 | -8.77 | -55.5 | 14.67 | 10.59 | |
| | | Max | -6.51 | -49.6 | 11.13 | -8.63 | -55.2 | 15.90 | 12.76 | |
| | | Min | -8.58 | -57.5 | 2.47 | -8.91 | -55.9 | 13.79 | 8.42 | |
| | | SD | 1.04 | 3.95 | 4.33 | 0.11 | 0.26 | 0.90 | 2.17 | |
| | Phreatic groundwater | Mean | -8.87 | -58.8 | 12.23 | -9.77 | -65.1 | 13.14 | 14.03 | |
| | | Max | -6.62 | -47.5 | 20.48 | -7.13 | -49.6 | 22.10 | 16.66 | |
| | | Min | -11.25 | -69.5 | 5.46 | -11.94 | -77.7 | 5.78 | 12.16 | |
| | | SD | 1.07 | 4.83 | 4.10 | 0.98 | 5.14 | 3.43 | 1.18 | |
| | Confined groundwater | Mean | -10.07 | -68.5 | 12.03 | -10.30 | -68.7 | 13.71 | 6.50 | |
| | | Max | -8.22 | -61.5 | 17.70 | -9.27 | -62.2 | 18.08 | 10.82 | |
| | | Min | -11.99 | -81.7 | 1.98 | -11.11 | -74.3 | 11.60 | B.D. | |
| | | SD | 0.90 | 4.60 | 3.63 | 0.53 | 3.08 | 1.65 | 3.52 | |
| Surface water | Mean | -10.84 | -74.0 | 12.71 | -10.84 | -72.2 | 13.61 | 1.93 | | |
| | Max | -9.87 | -66.6 | 15.36 | -9.57 | -65.9 | 19.48 | 8.54 | | |
| | Min | -12.12 | -85.0 | 1.49 | -11.53 | -77.8 | 0.00 | B.D. | | |
| | SD | 0.61 | 4.18 | 3.40 | 0.53 | 3.50 | 4.14 | 3.05 | | |
| Surface water | Mean | -9.95 | -69.0 | 10.58 | -9.88 | -69.7 | 9.34 | 7.64 | | |
| | Max | -7.35 | -59.6 | 16.56 | -9.08 | -66.0 | 13.21 | 9.57 | | |
| | Min | -11.36 | -74.3 | -0.80 | -11.01 | -74.9 | 6.64 | 6.51 | | |
| | SD | 1.84 | 6.69 | 8.05 | 0.83 | 3.80 | 2.81 | 1.37 | | |

| Watershed | Water type | | $\delta^{18}\text{O}$ | δD | d-excess | $\delta^{18}\text{O}$ | δD | d-excess | ^3H | Source | |
|----------------------|----------------------|---------------|-----------------------|------------------|----------|-----------------------|------------------|----------|--------------|--------|------|
| | | | (‰) | (‰) | (‰) | (‰) | (‰) | (‰) | (TU) | | |
| | | | Wet season | | | Dry season | | | | | |
| | Phreatic groundwater | Mean | -11.74 | -78.3 | 15.69 | -11.00 | -74.9 | 13.07 | 3.88 | | |
| | | Max | -10.66 | -70.3 | 16.86 | -7.89 | -62.5 | 17.35 | 13.08 | | |
| | | $N_W=15$ | Min | -12.70 | -87.4 | 14.22 | -12.04 | -80.0 | 0.58 | B.D. | |
| | | $N_D=11$ | SD | 0.47 | 3.86 | 0.71 | 1.24 | 5.8 | 4.86 | 4.83 | |
| | Confined groundwater | Mean | -12.01 | -80.9 | 15.22 | -11.24 | -76.28 | 13.63 | 2.16 | | |
| | | Max | | | | | | | | | |
| | | $N_W=1$ | Min | | | | | | | | |
| | | $N_D=1$ | SD | | | | | | | | |
| | Qaidam | Surface water | Mean | -8.79 | -61.6 | 8.74 | -9.63 | -67.2 | 9.78 | 9.88 | |
| | | | Max | -7.97 | -58.5 | 14.11 | -8.16 | -60.3 | 16.15 | 10.66 | |
| | | | $N_W=5$ | Min | -9.47 | -65.8 | 4.72 | -11.66 | -77.1 | 4.98 | 9.12 |
| | | | $N_D=3$ | SD | 0.56 | 3.00 | 3.65 | 1.49 | 7.2 | 4.69 | 0.63 |
| Phreatic groundwater | | Mean | -9.53 | -67.1 | 9.09 | -10.47 | -71.9 | 11.89 | 8.43 | | |
| | | Max | -9.05 | -65.2 | 10.82 | -9.02 | -65.1 | 15.46 | 8.76 | | |
| | | $N_W=6$ | Min | -9.94 | -68.7 | 7.16 | -11.64 | -77.7 | 7.11 | 7.95 | |
| | | $N_D=4$ | SD | 0.26 | 1.28 | 1.26 | 1.04 | 5.29 | 3.11 | 0.35 | |
| Confined groundwater | | Mean | | | | | | | | | |
| | | Max | | | | | | | | | |
| | | $N_W=0$ | Min | | | | | | | | |
| | | $N_D=0$ | SD | | | | | | | | |
| Qrhanwusu | Mean | -9.80 | -61.6 | 16.83 | -11.21 | -74.4 | 15.24 | | | | |
| | Max | | | | -10.78 | -71.6 | 16.24 | | | | |

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|----------------------------|----------------------|------|-----------------------|------------------|----------|-----------------------|------------------|----------|--------------|--------|
| | | | (‰) | (‰) | (‰) | (‰) | (‰) | (‰) | (‰) | |
| | | | Wet season | | | Dry season | | | | |
| Bayin | Surface water | Mean | -8.41 | -56.7 | 10.66 | -9.20 | -59.5 | 14.10 | 16.17 | |
| | | Max | -6.60 | -50.8 | 15.72 | -8.71 | -56.9 | 15.90 | 17.80 | |
| | | Min | -9.44 | -60.1 | -4.30 | -9.54 | -61.3 | 11.99 | 14.00 | |
| | | SD | 0.81 | 2.62 | 4.85 | 0.26 | 1.47 | 1.21 | 1.60 | |
| | Phreatic groundwater | Mean | -9.04 | -59.6 | 12.74 | -9.49 | -61.4 | 14.49 | 9.89 | |
| | | Max | -6.50 | -42.0 | 17.78 | -8.41 | -54.4 | 18.81 | 15.60 | |
| | | Min | -10.60 | -71.1 | 8.84 | -10.33 | -69.1 | 8.46 | 1.30 | |
| | | SD | 0.71 | 5.26 | 1.82 | 0.56 | 3.76 | 3.24 | 3.43 | |
| | Confined groundwater | Mean | -9.36 | -61.8 | 13.06 | -9.55 | -60.3 | 16.09 | 7.95 | |
| | | Max | -8.82 | -58.3 | 14.04 | -9.24 | -56.2 | 17.70 | 11.90 | |
| | | Min | -10.08 | -66.6 | 12.26 | -10.17 | -66.6 | 14.69 | 3.70 | |
| | | SD | 0.46 | 3.12 | 0.68 | 0.37 | 3.84 | 1.38 | 3.64 | |
| Eastern Kunlun Mountations | Rain water | Mean | -7.06 | -39.1 | 17.32 | | | | | |
| | | Max | 2.55 | 30.5 | 38.60 | | | | | |
| | | Min | -23.38 | -158.6 | -6.96 | | | | | |
| | | SD | 4.73 | 35.95 | 8.44 | | | | | |
| Snowmelt | Mean | | | | -13.64 | -87.7 | 21.43 | | | |
| | Max | | | | -11.30 | -61.7 | 31.65 | | | |
| | Min | | | | -19.30 | -152.0 | 2.38 | | | |
| | SD | | | | 2.92 | 33.33 | 10.23 | | | |
| Qilian Mountations | Rain water | Mean | -7.80 | -51.8 | 10.62 | | | | | |
| | | Max | 0.27 | 13.8 | 20.89 | | | | | |

Zhu et al., 2015

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|-----------|------------|------|-----------------------|------------------|----------|-----------------------|------------------|----------|--------------|-------------------|
| | | | (‰) | (‰) | (‰) | (‰) | (‰) | (‰) | (TU) | |
| | | | Wet season | | | Dry season | | | | |
| | | Min | -17.24 | -125.2 | 1.31 | | | | | |
| | | SD | 5.13 | 40.59 | 4.90 | | | | | |
| | | Mean | | | | -11.50 | -78.4 | 13.56 | | |
| | Snowmelt | Max | | | | -2.19 | 32.4 | 49.92 | | |
| | N=7 | Min | | | | -20.05 | -141.7 | -15.89 | | Yang et al., 2021 |
| | | SD | | | | 5.59 | 53.86 | 18.87 | | |

$N_{\text{W/D}}$ represents the number of samplings in wet/dry season; N represents the number of samplings of rain water or snowmelt; **B.D.** represents below the detection limit.

References

Yang, N., Zhou, P., Wang, G., Zhang, B., Shi, Z., Liao, F., Li, B., Chen, X., Guo, L., Dang, X., and Gu, X.: Hydrochemical and isotopic interpretation of interactions between surface water and groundwater in Delingha, Northwest China, *J. Hydrol.*, 598, 126243, <https://doi.org/10.1016/j.jhydrol.2021.126243>, 2021.

Zhu, J., Chen, H., and Gong, G.: Hydrogen and oxygen isotopic compositions of precipitation and its water vapor sources in Eastern Qaidam Basin, *Environmental Science*, 36(8), 2784-2790, <https://doi.org/10.13227/j.hjcx.2015.08.008>, 2015 (in Chinese with English abstract).

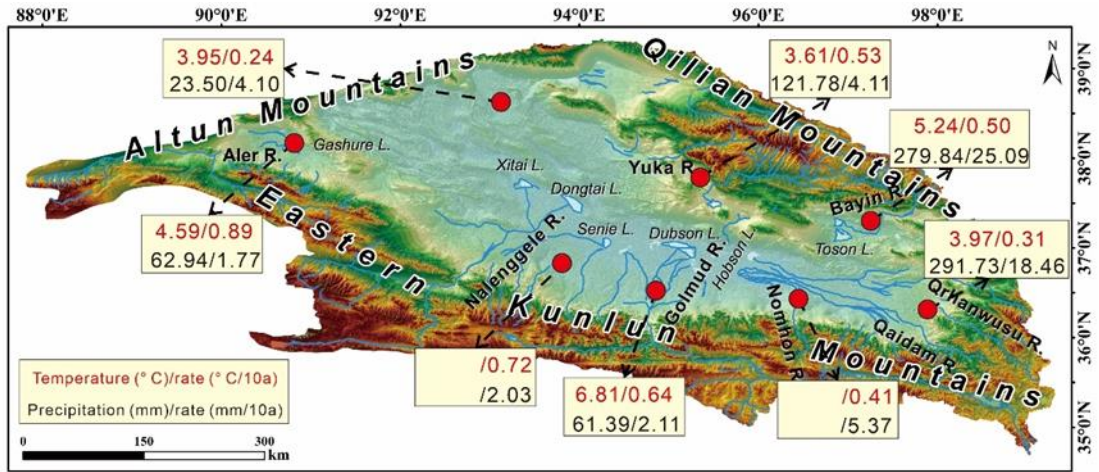


Figure S1. Average annual temperature and precipitation of each meteorological station in the Qaidam Basin since 2005 and rise in temperature and precipitation since 1961 (The rate data are from Yang et al., 2014).

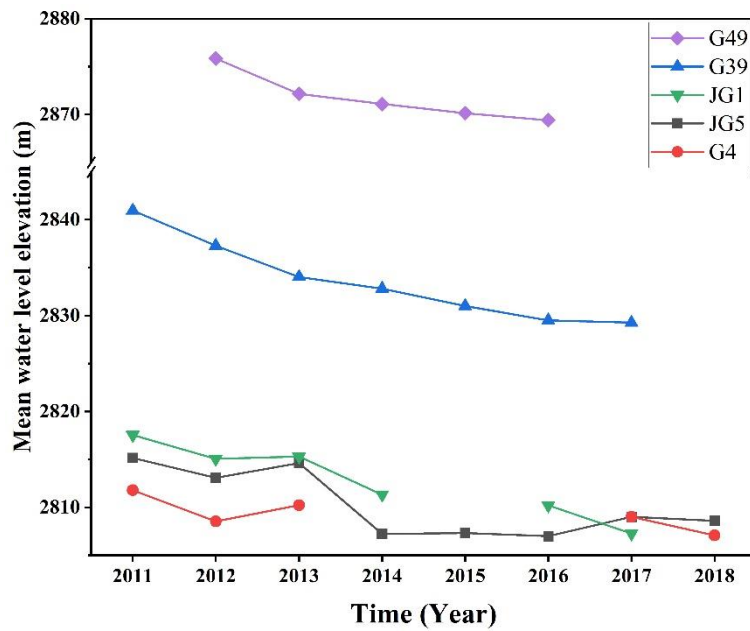


Figure S2. Changes in groundwater level in the Golmud River from 2011 to 2018.