Supplementary material

Table S1. Sites of Holocene precipitation reconstruction in the Mu Us Desert and adjacent area.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| No. | Site | Latitude/° | Longitude/° | Modern precipitation/mm | Holocene  precipitation/mm | Age | Methodology | Reference |
| 1 | HJN | 39.09 | 109.89 | 380 | 500 | - | Lake hydrologic modeling | This study |
| 2 | DLTR | 39.48 | 108.4 | 288 | 443 | 9.32-6.43ka B.P. |
| 3 | BZN | 38.75 | 108.82 | 322 | 471 | 7.83-5.97ka B.P.＊ |
| 4 | SRBDY | 39.25 | 108.29 | 279 | 444 | - |
| 5 | BJHZ | 39.79 | 109.33 | 317 | 472 | - |
| 6 | HJL | 39.11 | 110.09 | 385 | 510±25 | 7.5-5ka B.P. | Pollen | (Chen et al., 1993) |
| 7 | TB | 38.71 | 108.9 | 345 | 470±25 | Pollen |
| 8 | ABL | 39.79 | 110.4 | 375 | 497.58 | ~8-6ka B.P. | Pollen | (Shi et al., 1988) |
| 9 | LJY | 39.57 | 111.32 | 412 | 473.18 | Pollen |
| 10 | MLH | 40.01 | 108.09 | 230 | 342.91 | Pollen |
| 11 | WLX | 39.06 | 107.72 | 245 | 355.47 | Pollen |
| 12 | WS | 38.72 | 109 | 348 | 461.8 | Pollen |
| 13 | SLG | 39.81 | 109.68 | 348 | 478.06 | Pollen |
| 14 | HJP | 39.77 | 109.95 | 360 | 493.7 | Pollen |
| 15 | XM | 39.39 | 110.31 | 381 | 493.92 | Pollen |
| 16 | TL | 38.26 | 108.88 | 369 | 485.4 | Pollen |
| 17 | WLB | 39.22 | 107.95 | 257 | 365 | ~8.5-5ka B.P. | Pollen | (Shi, 1991) |
| 18 | CBWS | 38.72 | 107.27 | 267 | 361 | Pollen |
| 19 | DSG | 37.67 | 108.37 | 382 | 555.2 | Pollen |
| 20 | LX | 37.55 | 108.83 | 411 | 571.9 | Pollen |
| 21 | BTW | 37.95 | 108.84 | 383 | 480.1 | Pollen |
| 22 | LSW | 37.72 | 108.93 | 404 | 525±25 | 9-4ka | Pollen | (Huang, 1991) |
| 23 | GH | 38.91 | 112.23 | 445 | 556.5±17.5 | 11.5-3.3ka B.P. | Pollen | (Chen et al., 2015) |
| 24 | LC | 35.71 | 109.41 | 590 | 671 | 10.7-6.7ka B.P. | 10Be | (Zhang et al., 2020) |
| 25 | DH | 40.57 | 112.68 | 400 | 487.9 | 7.88-2.93ka B.P. | Pollen | (Xu et al., 2010a) |
| 26 | TC | 35.26 | 106.31 | 491 | 597.8 | Mid Holocene | Pollen | (Chen et al., 2018) |
| 27 | JLT | 39.71 | 105.7 | 140 | 246 | 8.5-3.5ka B.P. | Pollen | (Wu et al., 2018) |
| 28 | BJL | 39.06 | 104.13 | 143.5 | 251 | Mid-Holocene | Water balance model | (Liu and Li, 2017) |
| 29 | BJD | 39.93 | 102.29 | 100 | >200 | Early to  Mid-Holocene | - | (Yang and Williams, 2003) |
| 30 | DJHZ | 41.12 | 112.59 | 350 | 525±25 | 9.4-6.3ka B.P. | Pollen | (Shi and Song, 2003) |
| 31 | BYCG | 41.63 | 115.2 | 380 | 502.2 | 11-5.5ka B.P. | Pollen | (Jiang et al., 2006) |
| 32 | SV1 | 43.03 | 116.33 | 380 | 480 | Mid-Holocene | Surviving vegetation community | (Cui and Chen, 1993) |
| 33 | SV2 | 42.76 | 116.82 | 390 | 490 |
| 34 | SV3 | 43.52 | 118.79 | 400 | 500 |
| 35 | SV4 | 43.02 | 119.17 | 390 | 490 |
| 36 | SV5 | 42.89 | 119.6 | 410 | 510 |
| 37 | SV6 | 43.76 | 117.57 | 420 | 520 |
| 38 | CGL | 43.41 | 114.93 | 250 | 380 | 9.2-7ka B.P. | Pollen | (Li et al., 2020) |
| 39 | BYD | 38.85 | 116.03 | 547 | 747 | 7.6-3.7ka B.P. | Pollen | (Xu et al., 1988) |
| 40 | CDP | 36.1 | 114.4 | 550 | 657.5 | 9.26-4.36ka B.P. | Pollen | (Xu et al., 2010b) |
| 41 | MS | 34.94 | 113.37 | 645 | 825.7 | 11.2-4.9ka B.P. | GDGT | (Li and Gao, 2019) |
| 42 | LT | 34.2 | 109.2 | 650 | 815 | 8.3-4.4ka B.P. | GDGT | (Zhao et al., 2018) |
| 43 | MJY | 36.03 | 108.17 | 525 | 690±30 | 8.5-3.1ka B.P. | Magnetic susceptibility | (HUANG et al., 2004) |
| 44 | SLJ | 35.86 | 102.81 | 430 | 554 | ~7-4ka B.P. | GDGT | (Zhao et al., 2018) |
| 45 | QHL | 36.88 | 100.24 | 380 | 595±15 | 7.5-5ka B.P. | Water balance model | (Jia et al., 2000) |

＊The age data are quoted from Liu. (2018).

References:

Chen, F.H., Xu, Q.H., Chen, J.H., Birks, H.J.B., Liu, J. B., Zhang S. R., et al. (2015). East Asian Summer Monsoon Precipitation Variability since the Last Deglaciation. *Scientific Reports.* 5, 1-11. doi:10.1038/srep11186

Chen, J. H., Lv, F. Y., Huang, X. Z., Birks, H. J. B., Telford, R. J., Zhang, S. R., et.al. (2018). A Novel Procedure for Pollen-based Quantitative Paleoclimate Reconstructions and Its Application in China. *Science China Earth Sciences*. 60: 2059–2066, doi:10.1007/s11430-017-9095-1

Chen, W.N., Gao, S.Y., Shao, Y.J., and Zhang, H. L. (1993). Palynological Assemblages and Paleoclimatic Change of Mu Us Sandy Land during Holocene [J]. *Journal of Chinese Historical Geography*, 14(01), 22-30 (in Chinese with English abstract)

Cui. H.T., and Chen, K.Y. (1993). “Ecotone and Climate Change”. in Research on the Past Life-supporting Environment Change of China(I), edited L.S., Zhang (Beijing: Ocean Press),155-161. (in Chinese with English abstract)

Huang, C. C., Pang, J. L., Zhou, Q. Y., and Chen, S. E. (2004). Holocene Pedogenic Change and the Emergence and Decline of Rain-fed Cereal Agriculture on the Chinese Loess Plateau. *Quaternary Science Reviews.* 23(23-24), 2525-2535. doi:10.1016/j.quascirev.2004.06.003

Huang, C. X. 1991. The Changes of the Physical Environment of the Southern Maowusu Sandy Land during Holocene. *Geographical Research*. 10(02): 52-59+113 (in Chinese with English abstract)

Jia, Y.L., Shi, Y.F., and Fan, Y.Q. (2000). Water Balance of Paleolake Qinghai and Its Precipitation Estimation at Three High Lake-Level Stages since 40 ka B.P. *Journal of Lake Sciences.* 12(3),211-218. (in Chinese with English abstract) doi:10.18307/2000.0304

Jiang, W. Y., Guo, Z. T., Sun, X. J., Wu, H. B., Chu, G. Q., Yuan, B. Y., et al. (2006). Reconstruction of Climate and Vegetation Changes of Lake Bayanchagan (Inner Mongolia): Holocene Variability of the East Asian Monsoon. *Quaternary Research.* 65(3), 411-420. doi:10.1016/j.yqres.2005.10.007

Li, G. Q., Wang, Z., Zhao, W. W., Jin, M., Wang, X. Y., Tao, S. X., et al. (2020). Quantitative Precipitation Reconstructions from Chagan Nur Revealed Lag Response of East Asian Summer Monsoon Precipitation to Summer Insolation during the Holocene in Arid Northern China. *Quaternary Science Reviews*. 239, 106365. doi:10.1016/j.quascirev.2020.106365

Li, K. F., and Gao, W. H. (2019). Holocene Climate Change in Henan Area: a Synthesis of Proxy Records. *Quaternary International.* 521, 185-193. doi:10.1016/j.quaint.2019.05.026

Liu, J.R. (2018). Lake Level Fluctuation in the Mu Us Desert: a Case Study of Baozhainao Lake. Master Thesis. Beijing: Beijing Normal University.

Liu, Y., and Li, Y. (2017). Quantitative Reconstruction of Precipitation and Runoff during MIS 5a, MIS 3a, and Holocene, Arid China. *Theoretical and Applied Climatology.* 130, 747-754. doi:10.1007/s00704-016-1921-8

Shi, P. J., Jiang, T. M, and Liu, Q. F. (1988). Reconstruction of Precipitation during the Last Stage of the Late Pleistocene and the Middle Holocene in Ordos Plateau of North China. *Journal of Beijing Normal University (Natural Science)*. sup1.94-99. (in Chinese with English abstract)

Shi, P. J. (1991). Theory and Practice of Research into Geography Environment Changes—Research into Geographical Environment Change during Late Quaternary Period in the Ordos Region of North China. Beijing: Science Press (in Chinese)

Shi, P. J., and Song, C. Q. (2003). Palynological Records of Environmental Changes in the Middle Part of Inner Mongolia, China. *Chinese Science Bulletin.* 48(14), 1433-1438. doi:10.1360/02wd0259

Wu, Y.L., Wang, Y. B., Liu, X. Q., Yu, Z. T., and Ni, Z. Y. (2018). Holocene Climate Evolution in the Monsoonal Margin Region Revealed by the Pollen Record from Jilantai Playa. *Journal of Lake Sciences.* 30(4), 1161-1176. (in Chinese with English abstract) doi:10.18307/2018.0427

Xu, Q.H., Chen, S.Y., Kong, Z.C., and Du, N.Q. (1988). Preliminary Discussion of Vegetation Succession and Climate Change since the Holocene in the Baiyangdian Lake District. *Acta Phytoecological et Geobotanica Sinica.* 12(2). 65-73. (in Chinese with English abstract)

Xu, Q. H., Xiao, J. L., Li, Y. C., Tian, F., and Nakagawa, T. (2010a). Pollen-based Quantitative Reconstruction of Holocene Climate Changes in the Daihai Lake Area, Inner Mongolia, China. *Journal of Climate.* 23, 2856-2868. doi:10.1175/2009JCLI3155.1

Xu, Q. H., Li, Y. C., Bunting, M.J., Tian, F., and Liu, J. S. (2010b). The Effects of Training Set Selection on the Relationship Between Pollen Assemblages and Climate Parameters: Implications for Reconstructing Past Climate. *Palaeogeography, Palaeoclimatology, Palaeoecology.* 289, 123-133. doi:10.1016/j.palaeo.2010.02.024

Yang, X. P., and Williams, M.A.J. (2003). The Ion Chemistry of Lakes and Late Holocene Desiccation in the Badain Jaran Desert, Inner Mongolia, China. *Catena.* 51, 45-60. doi:10.1016/s0341-8162(02)00088-7

Zhang, C. J., Zhang, L., Zhang, W. Y., Tao, Y. H., Liu, Y., Wan, X. L. et al. (2020). Lake-level Oscillation based on Sediment Strata and Geochemical Proxies since 11,000 year from Tengger Nuur, Inner Mongolia, China. *Frontiers in Earth Science.* 8. doi:10.3389/feart.2020.00314

Zhao, H., Huang, C.C., Wang, H. Y., Liu, W. G., Qiang, X. K., Xu, X. W. et al. (2018). Mid-late Holocene Temperature and Precipitation Variations in the Guanting Basin, Upper Reaches of the Yellow River. *Quaternary International.* 490, 74-81. doi:10.1016/j.quaint.2018.05.009