



Supplement of

Disentangling the key drivers of water balance in Central Asia's Lake Balkhash: A relative contribution assessment

Ruibiao Yang et al.

Correspondence to: Jinglu Wu (w.jinglu@niglas.ac.cn)

The copyright of individual parts of the supplement might differ from the article licence.

Supplementary Material

Table S1. Chronological calibration/training and validation periods for each hydrological station and historical period.

| River System | Station | Period | Calibration/training years | Validation years | Temporal Resolution |
|---------------------|----------------|---------------|-----------------------------------|-------------------------|----------------------------|
| Ili | Ushzharma | P1 | 1931-1958 | 1959-1970 | Monthly, Yearly |
| Ili | Ushzharma | P2 | 1971-1984 | 1985-1989 | Monthly |
| Ili | Ushzharma | P3 | 1991-2011 | 2012-2020 | Yearly |
| Ili | Kapchagay | P1 | 1931-1958 | 1959-1970 | Monthly, Yearly |
| Ili | Kapchagay | P2 | 1971-1984 | 1985-1989 | Monthly |
| Ili | Kapchagay | P3 | 1991-1997 | 1998-2000 | Yearly |
| Ili | Dobyn | P1 | 1931-1958 | 1959-1970 | Yearly |
| Ili | Dobyn | P2 | 1971-1984 | 1985-1990 | Yearly |
| Ili | Dobyn | P3 | 1991-2011 | 2012-2020 | Yearly |
| Ili | Kairgan | P1 | 1931-1958 | 1959-1970 | Yearly |
| Ili | Kairgan | P2 | 1971-1984 | 1985-1990 | Yearly |
| Ili | Kairgan | P3 | 1991-2011 | 2012-2020 | Yearly |
| Ili | Yamate | P1 | 1953-1964 | 1965-1970 | Monthly |
| Ili | Yamate | P2 | 1971-1976 | 1977-1979 | Monthly |
| Ili | Tuohai | P1 | 1955-1965 | 1966-1970 | Monthly |
| Ili | Tuohai | P2 | 1971-1984 | 1985-1990 | Monthly, Yearly |
| Ili | Tuohai | P3 | 1991-2007 | 2008-2015 | Yearly |
| Ili | Qiafuqihai | P1 | 1958-1965 | 1966-1970 | Monthly |
| Ili | Qiafuqihai | P2 | 1971-1976 | 1977-1979 | Monthly |
| Ili | Sliyaniya_Su | P1 | 1936-1962 | 1963-1970 | Monthly |
| Ili | Sliyaniya_Su | P2 | 1971-1980 | 1981-1986 | Monthly |
| Ili | Sarytogay | P1 | 1935-1959 | 1960-1970 | Monthly |
| Ili | Sarytogay | P2 | 1971-1984 | 1985-1989 | Monthly |
| Ili | Sarytogay | P3 | 1991-2002 | 2003-2008 | Monthly |
| Ili | Malybay | P1 | 1936-1958 | 1959-1970 | Monthly |
| Ili | Malybay | P2 | 1971-1984 | 1985-1989 | Monthly |
| Ili | Malybay | P3 | 1991-2001 | 2002-2004 | Monthly |
| Karatal | Ushtobe | P1 | 1936-1959 | 1960-1970 | Monthly |
| Karatal | Ushtobe | P2 | 1971-1984 | 1985-1989 | Monthly |
| Karatal | Ushtobe | P3 | 1991-1997 | 1998-2000 | Yearly |
| Karatal | Tekeli | P1 | 1940-1962 | 1963-1970 | Monthly |
| Karatal | Tekeli | P2 | 1971-1979 | 1980-1986 | Monthly |
| Aksu | Chann | P1 | 1937-1959 | 1960-1970 | Monthly |
| Aksu | Chann | P2 | 1971-1977 | 1978-1983 | Monthly |
| Lepsy | Lepsy | P1 | 1936-1959 | 1960-1970 | Monthly |
| Lepsy | Lepsy | P2 | 1971-1980 | 1981-1989 | Monthly |
| Lepsy | Lepsinsk | P1 | 1936-1959 | 1960-1970 | Monthly |
| Lepsy | Lepsinsk | P2 | 1971-1980 | 1981-1985 | Monthly |
| Ayaguz | Ayaguz | P1 | 1949-1963 | 1964-1970 | Yearly |
| Ayaguz | Ayaguz | P2 | 1971-1981 | 1982-1986 | Yearly |

Table S2. Period-specific training and validation performance metrics for raw SEGSWAT+ simulations and hybrid corrected simulations.

| River System | Station | Period | Phase | KGE | KGE | NSE | NSE | PBIAS (%) | PBIAS (%) |
|--------------|--------------|--------|------------|------------|----------|------------|----------|------------|-----------|
| | | | | (SEGSWAT+) | (Hybrid) | (SEGSWAT+) | (Hybrid) | (SEGSWAT+) | (Hybrid) |
| Ili | Ushzharma | P1 | Training | 0.671 | 0.913 | 0.854 | 0.929 | -16.8 | 2.54 |
| Ili | Ushzharma | P1 | Validation | 0.606 | 0.867 | 0.689 | 0.923 | -16.3 | 2.04 |
| Ili | Ushzharma | P2 | Training | 0.624 | 0.831 | 0.703 | 0.923 | -18.34 | 7.01 |
| Ili | Ushzharma | P2 | Validation | 0.614 | 0.826 | 0.693 | 0.913 | -17.84 | 6.51 |
| Ili | Ushzharma | P3 | Training | 0.717 | 0.848 | 0.83 | 0.858 | -12.08 | 6.5 |
| Ili | Ushzharma | P3 | Validation | 0.653 | 0.756 | 0.663 | 0.759 | -11.58 | 5.48 |
| Ili | Kapchagay | P1 | Training | 0.596 | 0.873 | 0.735 | 0.874 | 4.81 | 4.31 |
| Ili | Kapchagay | P1 | Validation | 0.479 | 0.863 | 0.703 | 0.864 | 4.17 | 3.67 |
| Ili | Kapchagay | P2 | Training | 0.525 | 0.814 | 0.654 | 0.815 | 4.83 | 1.79 |
| Ili | Kapchagay | P2 | Validation | 0.515 | 0.804 | 0.644 | 0.805 | -4.33 | -1.72 |
| Ili | Kapchagay | P3 | Training | 0.245 | 0.761 | 0.255 | 0.923 | -6.97 | -6.54 |
| Ili | Kapchagay | P3 | Validation | 0.058 | 0.751 | 0.068 | 0.921 | 0.81 | 0.06 |
| Ili | Dobyn | P1 | Training | 0.606 | 0.901 | 0.79 | 0.902 | 1.23 | 0.73 |
| Ili | Dobyn | P1 | Validation | 0.48 | 0.898 | 0.705 | 0.899 | 0.35 | 0.26 |
| Ili | Dobyn | P2 | Training | 0.496 | 0.824 | 0.591 | 0.825 | 8.06 | 7.56 |
| Ili | Dobyn | P2 | Validation | 0.444 | 0.814 | 0.581 | 0.815 | -4.78 | -4.28 |
| Ili | Dobyn | P3 | Training | 0.616 | 0.808 | 0.69 | 0.874 | 6.54 | 6.04 |
| Ili | Dobyn | P3 | Validation | 0.579 | 0.798 | 0.618 | 0.864 | 3.74 | 3.48 |
| Ili | Kairgan | P1 | Training | 0.626 | 0.846 | 0.689 | 0.859 | 2.8 | 2.3 |
| Ili | Kairgan | P1 | Validation | 0.58 | 0.836 | 0.679 | 0.849 | -0.84 | -0.54 |
| Ili | Kairgan | P2 | Training | 0.546 | 0.904 | 0.549 | 0.905 | 5.99 | 5.49 |
| Ili | Kairgan | P2 | Validation | 0.43 | 0.894 | 0.546 | 0.895 | 1.69 | 1.47 |
| Ili | Kairgan | P3 | Training | 0.607 | 0.763 | 0.698 | 0.92 | 4.29 | 1.79 |
| Ili | Kairgan | P3 | Validation | 0.6 | 0.753 | 0.602 | 0.91 | 3.71 | 1.72 |
| Ili | Yamate | P1 | Training | 0.547 | 0.927 | 0.708 | 0.929 | -4.35 | -3.85 |
| Ili | Yamate | P1 | Validation | 0.516 | 0.917 | 0.698 | 0.927 | 1.27 | 1.13 |
| Ili | Yamate | P2 | Training | 0.625 | 0.928 | 0.633 | 0.929 | 5.66 | 3.13 |
| Ili | Yamate | P2 | Validation | 0.552 | 0.925 | 0.594 | 0.926 | 3.05 | 2.55 |
| Ili | Tuohai | P1 | Training | 0.512 | 0.891 | 0.697 | 0.892 | 6.99 | 6.49 |
| Ili | Tuohai | P1 | Validation | 0.451 | 0.881 | 0.687 | 0.882 | -3.36 | -2.86 |
| Ili | Tuohai | P2 | Training | 0.536 | 0.9 | 0.739 | 0.901 | 1.99 | 0.67 |
| Ili | Tuohai | P2 | Validation | 0.49 | 0.882 | 0.689 | 0.883 | 1.25 | 0.39 |
| Ili | Tuohai | P3 | Training | 0.579 | 0.899 | 0.68 | 0.926 | -9.15 | -8.65 |
| Ili | Tuohai | P3 | Validation | 0.569 | 0.889 | 0.67 | 0.925 | 2.3 | 1.53 |
| Ili | Qiafuqihai | P1 | Training | 0.562 | 0.801 | 0.738 | 0.92 | 4.85 | 4.35 |
| Ili | Qiafuqihai | P1 | Validation | 0.522 | 0.754 | 0.701 | 0.91 | -4.19 | -3.69 |
| Ili | Qiafuqihai | P2 | Training | 0.62 | 0.849 | 0.805 | 0.85 | -3.47 | -2.97 |
| Ili | Qiafuqihai | P2 | Validation | 0.421 | 0.755 | 0.597 | 0.758 | -3.38 | -2.88 |
| Ili | Sliyaniya Su | P1 | Training | 0.598 | 0.874 | 0.767 | 0.875 | 3.15 | 1.92 |
| Ili | Sliyaniya Su | P1 | Validation | 0.522 | 0.864 | 0.701 | 0.865 | 2.49 | 1.43 |
| Ili | Sliyaniya Su | P2 | Training | 0.681 | 0.804 | 0.746 | 0.805 | -4.19 | -3.07 |
| Ili | Sliyaniya Su | P2 | Validation | 0.585 | 0.788 | 0.681 | 0.789 | -3.98 | -2.68 |

| | | | | | | | | | |
|---------|-----------|----|------------|-------|-------|-------|-------|--------|-------|
| Ili | Sarytogay | P1 | Training | 0.603 | 0.806 | 0.754 | 0.831 | 4.39 | 3.89 |
| Ili | Sarytogay | P1 | Validation | 0.575 | 0.796 | 0.744 | 0.797 | -1.53 | -1.02 |
| Ili | Sarytogay | P2 | Training | 0.686 | 0.791 | 0.769 | 0.801 | -1.4 | -1.29 |
| Ili | Sarytogay | P2 | Validation | 0.529 | 0.756 | 0.552 | 0.759 | 1.13 | 0.88 |
| Ili | Sarytogay | P3 | Training | 0.584 | 0.884 | 0.719 | 0.885 | 6.63 | 1.84 |
| Ili | Sarytogay | P3 | Validation | 0.566 | 0.829 | 0.631 | 0.83 | 6.14 | 1.61 |
| Ili | Malybay | P1 | Training | 0.595 | 0.837 | 0.777 | 0.838 | -3.62 | -3.12 |
| Ili | Malybay | P1 | Validation | 0.574 | 0.781 | 0.752 | 0.782 | -3.01 | -2.51 |
| Ili | Malybay | P2 | Training | 0.47 | 0.886 | 0.674 | 0.887 | 4.34 | 3.84 |
| Ili | Malybay | P2 | Validation | 0.46 | 0.876 | 0.664 | 0.877 | -2.86 | -1.12 |
| Ili | Malybay | P3 | Training | 0.511 | 0.892 | 0.645 | 0.925 | 3.99 | 3.86 |
| Ili | Malybay | P3 | Validation | 0.48 | 0.882 | 0.635 | 0.924 | -2.81 | -1.06 |
| Karatal | Ushtobe | P1 | Training | 0.796 | 0.912 | 0.873 | 0.921 | 16.29 | 7.99 |
| Karatal | Ushtobe | P1 | Validation | 0.757 | 0.873 | 0.767 | 0.885 | 15.28 | 7.7 |
| Karatal | Ushtobe | P2 | Training | 0.696 | 0.817 | 0.853 | 0.922 | 18.06 | 9.9 |
| Karatal | Ushtobe | P2 | Validation | 0.679 | 0.786 | 0.759 | 0.883 | 15.1 | 4.54 |
| Karatal | Ushtobe | P3 | Training | 0.621 | 0.83 | 0.636 | 0.84 | -20.38 | -8.59 |
| Karatal | Ushtobe | P3 | Validation | 0.611 | 0.774 | 0.626 | 0.784 | 19.88 | 8.09 |
| Karatal | Tekeli | P1 | Training | 0.602 | 0.761 | 0.652 | 0.769 | -5.15 | -4.65 |
| Karatal | Tekeli | P1 | Validation | 0.57 | 0.757 | 0.64 | 0.759 | 1.53 | 1.03 |
| Karatal | Tekeli | P2 | Training | 0.549 | 0.884 | 0.761 | 0.885 | 3.53 | 3.03 |
| Karatal | Tekeli | P2 | Validation | 0.52 | 0.838 | 0.75 | 0.839 | -3.28 | -2.78 |
| Aksu | Chann | P1 | Training | 0.706 | 0.754 | 0.721 | 0.784 | -11.55 | -7.31 |
| Aksu | Chann | P1 | Validation | 0.696 | 0.744 | 0.711 | 0.774 | -11.05 | -6.81 |
| Aksu | Chann | P2 | Training | 0.662 | 0.76 | 0.672 | 0.927 | -13.84 | -7.31 |
| Aksu | Chann | P2 | Validation | 0.479 | 0.75 | 0.489 | 0.753 | -13.34 | -6.81 |
| Lepsey | Lepsey | P1 | Training | 0.692 | 0.921 | 0.697 | 0.922 | -10.93 | -7.58 |
| Lepsey | Lepsey | P1 | Validation | 0.682 | 0.911 | 0.687 | 0.912 | 3.1 | 1.06 |
| Lepsey | Lepsey | P2 | Training | 0.592 | 0.826 | 0.728 | 0.827 | -4.6 | -4.17 |
| Lepsey | Lepsey | P2 | Validation | 0.458 | 0.756 | 0.608 | 0.758 | -2.92 | -0.08 |
| Lepsey | Lepsinsk | P1 | Training | 0.664 | 0.819 | 0.674 | 0.829 | 11.29 | -6.36 |
| Lepsey | Lepsinsk | P1 | Validation | 0.626 | 0.751 | 0.636 | 0.757 | 10.79 | -5.72 |
| Lepsey | Lepsinsk | P2 | Training | 0.652 | 0.794 | 0.75 | 0.861 | 10.45 | -6.18 |
| Lepsey | Lepsinsk | P2 | Validation | 0.642 | 0.761 | 0.705 | 0.801 | 10.22 | -5.68 |
| Ayaguz | Ayaguz | P1 | Training | 0.774 | 0.87 | 0.784 | 0.88 | -25.04 | 3.97 |
| Ayaguz | Ayaguz | P1 | Validation | 0.764 | 0.86 | 0.774 | 0.87 | -4.12 | -3.47 |
| Ayaguz | Ayaguz | P2 | Training | 0.56 | 0.826 | 0.57 | 0.921 | -12.93 | -3.25 |
| Ayaguz | Ayaguz | P2 | Validation | 0.55 | 0.801 | 0.56 | 0.811 | -12.43 | 0.75 |