

Table S1. The meteorological stations we collected before 1900. The detailed information includes latitude, longitude, observation elements, start and end year. The WMO station number is recorded after the station name (abbreviations).

| Station name | Latitude | Longitude | Observation Elements | Start Year | End Year |
|----------------------|----------|-----------|-------------------------|------------|----------|
| SWE00100026 | 63.18 | 14.48 | TMIN | 1882 | 2022 |
| CA002100398 | 64.07 | -139.33 | TMAX | 1898 | 1901 |
| CA002100400 | 64.05 | -139.43 | TMAX | 1897 | 1979 |
| CA002100635 | 69.50 | -139.25 | TMAX | 1896 | 1918 |
| CA002100880 | 62.82 | -137.37 | TMAX | 1898 | 2017 |
| GLE00100981 | 69.22 | -51.05 | TMIN | 1873 | 1960 |
| CA002101290 | 60.72 | -135.05 | TMAX | 1900 | 1960 |
| CA002201600 | 67.43 | -134.88 | TMAX | 1892 | 1977 |
| USC00501977 | 65.83 | -144.07 | TMIN | 1900 | 1999 |
| SWM00002080 | 68.44 | 22.45 | TMIN | 1882 | 2012 |
| CA002202100 | 61.87 | -121.35 | TMAX | 1895 | 1963 |
| FORT_SIMPSON2202102 | 61.77 | -121.23 | | 1895 | 2021 |
| SW000002120 | 66.96 | 17.73 | TMIN | 1887 | 2013 |
| SW000002196 | 65.83 | 24.14 | TMIN | 1882 | 2013 |
| SW000002361 | 62.63 | 17.93 | TMIN | 1882 | 2022 |
| CA002202398 | 60.85 | -115.95 | TMAX | 1893 | 1943 |
| HAY_RIVER2202402 | 60.83 | -115.78 | | 1893 | 2021 |
| USC00503162 | 61.10 | -146.45 | TMIN | 1900 | 1916 |
| USC00503655 | 62.18 | -159.77 | TMIN | 1892 | 1975 |
| GL000004360 | 65.60 | -37.63 | TMIN | 1894 | 2022 |
| NOE00105494 | 70.37 | 31.08 | TMIN | 1900 | 2022 |
| USC00506844 | 60.58 | -145.68 | TMIN | 1899 | 1908 |
| USC00507669 | 65.25 | -166.87 | TMIN | 1895 | 1995 |
| USC00507891 | 65.50 | -150.25 | TMIN | 1900 | 1933 |
| USC00508102 | 62.25 | -163.75 | TMIN | 1893 | 1898 |
| USC00508114 | 63.48 | -162.02 | TMIN | 1899 | 1933 |
| USC00509494 | 61.07 | -151.13 | TMIN | 1898 | 1970 |
| SW000010537 | 60.62 | 15.62 | TMIN | 1900 | 2022 |
| Malye Karmakuly20744 | 72.37 | 52.70 | | 1876 | 2022 |
| RSM00022003 | 69.93 | 31.98 | TAVG | 1894 | 2013 |
| RSM00022028 | 69.20 | 35.10 | TAVG | 1893 | 2022 |
| RSM00022140 | 68.15 | 39.82 | TAVG | 1895 | 2013 |
| RSM00022355 | 66.48 | 40.68 | TAVG | 1862 | 2013 |

| Station name | Latitude | Longitude | Observation Elements | Start Year | End Year |
|---------------------|----------|-----------|-------------------------|------------|----------|
| Zizgin22438 | 65.20 | 36.82 | | 1859 | 2022 |
| Kem'-Port22520 | 64.98 | 34.80 | | 1863 | 2022 |
| RSM00022550 | 64.50 | 40.73 | TAVG | 1813 | 2022 |
| Onega22641 | 63.90 | 38.12 | | 1887 | 2022 |
| RSM00022768 | 62.10 | 42.90 | TAVG | 1884 | 2022 |
| Sortavala22802 | 61.72 | 30.72 | | 1881 | 2022 |
| RSM00022837 | 61.02 | 36.45 | TAVG | 1878 | 2022 |
| RSM00022845 | 61.50 | 38.93 | TAVG | 1883 | 2022 |
| Vyborg22892 | 60.72 | 28.73 | | 1884 | 2022 |
| RSM00022907 | 60.08 | 26.97 | TAVG | 1865 | 1994 |
| RSM00023330 | 66.53 | 66.53 | TAVG | 1882 | 2022 |
| RSM00023405 | 65.43 | 52.27 | TAVG | 1889 | 2022 |
| Turuhansk23472 | 65.78 | 87.93 | | 1843 | 2022 |
| Tarko-Sale23552 | 64.92 | 77.82 | | 1843 | 2022 |
| Berezovo23631 | 63.93 | 65.05 | | 1834 | 2022 |
| RSM00023711 | 62.70 | 56.20 | TAVG | 1888 | 2022 |
| RSM00023804 | 61.67 | 50.87 | TAVG | 1817 | 2022 |
| RSM00023849 | 61.25 | 73.50 | TAVG | 1884 | 2022 |
| RSM00023914 | 60.40 | 56.52 | TAVG | 1888 | 2022 |
| RSM00023933 | 61.02 | 69.12 | TAVG | 1892 | 2022 |
| RSM00024266 | 67.57 | 133.40 | TAVG | 1869 | 2022 |
| RSM00024641 | 63.78 | 121.62 | TAVG | 1863 | 2022 |
| Suntar24738 | 62.15 | 117.65 | | 1900 | 2022 |
| RSM00024944 | 60.40 | 120.42 | TAVG | 1882 | 2022 |
| RSM00024959 | 62.02 | 129.72 | TAVG | 1834 | 2022 |
| RSM00024966 | 60.38 | 134.45 | TAVG | 1893 | 2022 |
| Srednekolym'sk25206 | 67.45 | 153.72 | | 1887 | 2022 |
| RSM00025551 | 64.68 | 170.42 | TAVG | 1894 | 2022 |
| RSM00025563 | 64.78 | 177.57 | TAVG | 1889 | 2022 |
| USW00026413 | 66.57 | -145.23 | TMIN | 1899 | 1990 |
| USW00026523 | 60.58 | -151.24 | TMIN | 1899 | 2022 |
| USW00026616 | 66.87 | -162.63 | TMIN | 1897 | 2022 |
| USW00026617 | 64.51 | -165.44 | TMIN | 1900 | 2022 |
| SWE00139430 | 60.65 | 17.17 | TMIN | 1882 | 1995 |
| SWE00139694 | 61.85 | 16.58 | TMIN | 1882 | 1966 |
| SWE00139720 | 62.02 | 14.19 | TMIN | 1882 | 2012 |

| Station name | Latitude | Longitude | Observation Elements | Start Year | End Year |
|--------------|----------|-----------|-------------------------|------------|----------|
| SWE00140022 | 63.32 | 12.10 | TMIN | 1882 | 1964 |
| SWE00140132 | 63.68 | 16.95 | TMIN | 1899 | 2008 |
| SWE00140186 | 63.83 | 20.28 | TMIN | 1882 | 1979 |
| SWE00140492 | 65.32 | 21.49 | TMIN | 1882 | 2022 |
| SWE00140594 | 65.72 | 15.25 | TMIN | 1892 | 1972 |
| SWE00140746 | 66.63 | 19.64 | TMIN | 1882 | 2018 |
| SWE00140828 | 67.14 | 20.65 | TMIN | 1888 | 2022 |
| NOE00157204 | 69.32 | 16.12 | TMIN | 1876 | 1972 |
| NO000097250 | 69.47 | 25.50 | TMIN | 1900 | 2004 |

Table S2. The sitenames of tree ring used for summer Arctic temperature reconstructions. All tree ring data were obtained in International Tree Ring Data Bank. Postscript means e = earlywood width; i = earlywood density; l = latewood width; t = latewood density and x = maximum latewood density. The star means the site was used for reconstruction in all four detrending methods.

| Sitename | | | | | | |
|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| ak006t* | ak006x* | ak010t* | ak010x* | ak035 | ak037 | ak039 |
| ak037 | ak039 | ak048 | ak051 | ak057* | ak060 | ak062 |
| ak060 | ak062 | ak063 | ak072x* | ak075x | ak077x* | ak078 |
| ak077x* | ak078 | ak078x* | ak087 | ak088 | ak089* | ak110 |
| ak089* | ak110 | ak115x | ak116x* | ak117x | ak132x* | ak148 |
| ak132x* | ak148 | ak149 | ak151* | cana319x | cana321x | cana340 |
| cana321x | cana340 | cana360 | cana376 | cana4 | cana510 | cana512 |
| cana510 | cana512 | cana513 | cana514 | finl021* | finl022* | finl045 |
| finl022* | finl045 | finl047 | finl052* | finl055* | finl055e* | finl055l* |
| finl055e* | finl055l* | finl060* | finl061* | finl062 | finl063 | finl066* |
| finl063 | finl066* | finl069x* | finl070* | finl070* | finl070x* | finl071x* |
| finl070x* | finl071x* | finl072* | finl072* | finl072x* | finl073x* | finl074* |
| finl073x* | finl074* | finl074* | finl074x* | norw007 | norw008* | norw009* |
| norw008* | norw009* | norw010* | norw011* | norw011e* | norw011l* | norw012* |
| norw011l* | norw012* | norw012e* | norw012l | russ016 | russ019 | russ021e |
| russ019 | russ021e | russ021l* | russ021t* | russ021w* | russ021x* | russ022e |
| russ021x* | russ022e | russ022t | russ022x | russ023e | russ023t* | russ023w |
| russ023t* | russ023w | russ023x* | russ024e* | russ024e* | russ024t* | russ024w |
| russ024t* | russ024w | russ024x* | russ025e* | russ025e* | russ025l | russ025t* |
| russ025l | russ025t* | russ025w* | russ025x* | russ027e* | russ027e* | russ027i* |

| Sitename | | | | | | |
|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| russ027e* | russ027i* | russ027i* | russ027t* | russ027w* | russ027x* | russ028e* |
| russ027x* | russ028e* | russ028e* | russ028i* | russ028t* | russ028w* | russ028x* |
| russ028w* | russ028x* | russ029e | russ029i* | russ029i* | russ029l | russ029l |
| russ029l | russ029l | russ029t* | russ029w* | russ029x* | russ030e* | russ030e* |
| russ030e* | russ030e* | russ030l | russ030t* | russ030w* | russ030x* | russ031e* |
| russ030x* | russ031e* | russ031e* | russ031l* | russ031t* | russ031w* | russ031x* |
| russ031w* | russ031x* | russ032e* | russ032e* | russ032l | russ032t* | russ032w* |
| russ032t* | russ032w* | russ032x* | russ033e* | russ033e* | russ033t* | russ033w* |
| russ033t* | russ033w* | russ033x* | russ034e* | russ034e* | russ034t* | russ034w* |
| russ034t* | russ034w* | russ034x* | russ035e* | russ035e* | russ035i* | russ035i* |
| russ035i* | russ035i* | russ035l* | russ035n | russ035t* | russ035w* | russ035x* |
| russ035w* | russ035x* | russ036e | russ036t* | russ036w | russ036x* | russ037i* |
| russ036x* | russ037i* | russ037t* | russ037x* | russ038e* | russ038t* | russ038w* |
| russ038t* | russ038w* | russ038x* | russ039t* | russ039x* | russ040e | russ040t* |
| russ040e | russ040t* | russ040w | russ040x* | russ041e* | russ041e* | russ041l* |
| russ041e* | russ041l* | russ041l* | russ041t* | russ041w* | russ041x* | russ042t* |
| russ041x* | russ042t* | russ042x* | russ043e* | russ043t* | russ043w* | russ043x* |
| russ043w* | russ043x* | russ044i | russ044l* | russ044n | russ044t* | russ044x* |
| russ044t* | russ044x* | russ045l* | russ045l* | russ045t* | russ045w | russ045x* |
| russ045w | russ045x* | russ046e | russ046t* | russ046w | russ046x* | russ047t* |
| russ046x* | russ047t* | russ047x* | russ048e* | russ048l | russ048t | russ048w* |
| russ048t | russ048w* | russ048x* | russ049t | russ049x | russ050t* | russ050x* |
| russ050t* | russ050x* | russ052e | russ052t | russ052w | russ052x* | russ053t |
| russ052x* | russ053t | russ053x | russ056e* | russ056e* | russ056t* | russ056w* |
| russ056t* | russ056w* | russ056x* | russ057x | russ058e* | russ058e* | russ058t* |
| russ058e* | russ058t* | russ058w* | russ058x* | russ059t | russ059x | russ060t* |
| russ059x | russ060t* | russ060x* | russ061i | russ061t* | russ061x* | russ062e* |
| russ061x* | russ062e* | russ062e* | russ062t* | russ062w* | russ062x* | russ063t |
| russ062x* | russ063t | russ063x | russ064e | russ064i* | russ064i* | russ064l |
| russ064i* | russ064l | russ064t* | russ064w | russ064x* | russ065e* | russ065e* |
| russ065e* | russ065e* | russ065l* | russ065t | russ065w* | russ065x* | russ066e* |
| russ065x* | russ066e* | russ066e* | russ066w | russ069t* | russ069x* | russ070e* |
| russ069x* | russ070e* | russ070l | russ070t | russ070w* | russ070x* | russ071e* |
| russ070x* | russ071e* | russ071t* | russ071w* | russ071x* | russ072t | russ073e |
| russ072t | russ073e | russ073t* | russ073w* | russ073x* | russ074t* | russ074x* |
| russ074t* | russ074x* | russ075i* | russ075n* | russ075t* | russ075x* | russ076i |
| russ075x* | russ076i | russ076l* | russ076n | russ076t* | russ076x* | russ077t* |

| Sitename | | | | | | |
|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| russ076x* | russ077t* | russ077x* | russ078e | russ078t* | russ078w | russ078x* |
| russ078w | russ078x* | russ079t* | russ079x* | russ080e | russ080i* | russ080l* |
| russ080i* | russ080l* | russ080t* | russ080w* | russ080x* | russ082i | russ082l* |
| russ082i | russ082l* | russ082t* | russ082w | russ082x* | russ083t* | russ083x* |
| russ083t* | russ083x* | russ084i | russ084t* | russ084x* | russ085e* | russ085e* |
| russ085e* | russ085e* | russ085w* | russ086l | russ086w | russ087e | russ087l |
| russ087e | russ087l | russ087t* | russ087w | russ087x* | russ088t* | russ088x* |
| russ088t* | russ088x* | russ090e | russ090l | russ090w | russ091t | russ091x |
| russ091t | russ091x | russ092i* | russ092l | russ092t* | russ092x* | russ093e* |
| russ092x* | russ093e* | russ093t* | russ093w | russ093x* | russ094e* | russ094l* |
| russ094e* | russ094l* | russ094t* | russ094w* | russ094x* | russ095i | russ095t* |
| russ095i | russ095t* | russ095x* | russ096t* | russ096x* | russ097t* | russ097x* |
| russ097t* | russ097x* | russ099e* | russ099e* | russ099i* | russ099l | russ099t* |
| russ099l | russ099t* | russ099w* | russ099x* | russ100e | russ100i* | russ100l |
| russ100i* | russ100l | russ100t* | russ100w | russ100x* | russ101e | russ101t* |
| russ101e | russ101t* | russ101w | russ101x* | russ102t | russ102x* | russ103e |
| russ102x* | russ103e | russ103l | russ103t* | russ103w | russ103x* | russ104t* |
| russ103x* | russ104t* | russ104x* | russ105e* | russ105w | russ107e* | russ107t* |
| russ107e* | russ107t* | russ107w* | russ107x* | russ111e | russ111i | russ111l |
| russ111i | russ111l | russ111t* | russ111w | russ111x* | russ112e | russ114i* |
| russ112e | russ114i* | russ114t* | russ114x* | russ115i | russ115t* | russ115x* |
| russ115t* | russ115x* | russ116t* | russ116x* | russ117i | russ117t* | russ117x* |
| russ117t* | russ117x* | russ119e | russ119i* | russ119l | russ119t* | russ119w |
| russ119t* | russ119w | russ119x* | russ120i* | russ120i* | russ120t* | russ120w |
| russ120t* | russ120w | russ120x* | russ177e* | russ177t* | russ177w* | russ177x* |
| russ177w* | russ177x* | russ178e* | russ178l* | russ178t* | russ178w* | russ178x* |
| russ178w* | russ178x* | russ180i* | russ180l* | russ180t* | russ180w* | russ180x* |
| russ180w* | russ180x* | russ182* | russ183 | russ184* | russ185* | russ187* |
| russ185* | russ187* | russ188* | russ189* | russ191* | russ192* | russ194 |
| russ192* | russ194 | russ195 | russ196 | russ197 | russ198 | russ199* |
| russ198 | russ199* | russ202* | russ204 | russ205 | russ207 | russ208* |
| russ207 | russ208* | russ216* | russ220 | russ221* | russ223* | russ237 |
| russ223* | russ237 | russ237n* | russ237x* | russ238* | russ238* | russ238n* |
| russ238* | russ238n* | russ238x* | russ239* | russ239n* | russ239x* | swed018 |
| russ239x* | swed018 | swed306 | swed318 | swed327 | swed330 | swed330x* |
| swed330 | swed330x* | swed331* | swed331x* | swed332 | swed332x* | swed333* |
| swed332x* | swed333* | swed333* | swed333x* | | | |

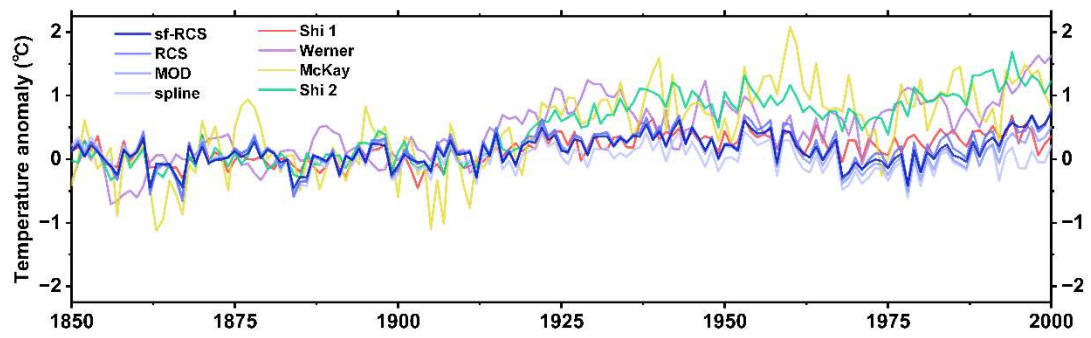


Figure S1. Arctic summer temperature anomalies relative to 1850-1900 for previous and our reconstructions.