Supplement

Northern Hemisphere temperature patterns in the last 12 centuries

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Tests of robustness

In order to investigate the robustness of the observed spatial patterns we performed five different experiments on discrete subsets of the 120 proxy records. In all experiments the treatment of the proxy data is the same as that described in the methods sections of this supplement.

Experiment 1: Excluding one proxy data type at a time in comparison to the full data set consisting of 8 proxy data types.

Results:

- Excluding Documentary records (6 in number) does not affects the results (Fig. S1).
- Excluding Ice-core records (10 in number) reduces the warming over Greenland in the 10th century and leaves the northeastern part of Greenland without coverage in all 12 centuries (Fig. S2).
- Excluding Lake sediment records (28 in number) results in a lack of coverage over Alaska in addition to producing somewhat lower anomalies over China in the 17th century (Fig. S3).
- Excluding Pollen records (13 in number) reduces the coverage over eastern North America (Fig. S4).
- Excluding Sea sediment records (19 in number) results in no notable changes in either coverage or spatial patterns observed (Fig. S5).
- Excluding Speleothem records (8 in number) results in no notable changes in either coverage or spatial patterns observed (Fig. S6).
- Excluding Tree-ring records (30 in number) leaves the southwest United States without cover. Excluding tree-ring records gives a cooler MWP over Asia and reduces the warmth over Europe during the 20th century (Fig. S7).
- Excluding Other records (6 in number) results in no notable changes in either coverage or spatial patterns observed (Fig. S8).

Experiment 2: Using only those proxies (52 in number) that begin before 816 AD and end after 1984.

Note: All 120 proxy records are 100% complete from the 11th to 19th centuries, but many have less than 85 years of data coverage in one or more of the 9th, 10th and 20th centuries and thus do not contribute any information for those centuries. This experiment excludes those records that do not span (>85%) all twelve centuries.

Results: This experiment excludes the majority of pollen and sea sediment records and some lake sediment records. It emphasizes the influence of tree-ring and lake sediment records. The overall coverage is not much affected with the exception of eastern North America where no records satisfy the condition (Fig. S9).

Experiment 3: Using only proxies with 4 or more (85 in number) and also with 10 or more (65 in number) observations per century.

Results: Using only proxies with 4 or more observations per century, mainly excludes pollen records, many sea sediment records and some lake sediment records. This leaves eastern United States without coverage (Fig. S10). The MWP gets less warm in North America.

Using only proxies with 10 or more observations per century, further excludes many lake sediment records. The surviving records are primarily documentary, ice-core, speleothem and tree-ring records. This still gives similar patterns as above but with less spatial coverage (Fig. 11).

Experiment 4: Requiring all proxies used must have data coverage up to 1995 (34 in number).

Results: Using only proxies that have data coverage up to 1995 significantly decreases the hemispheric coverage, except in Europe, and produces a warmer 17th century and colder 19th century in China (Fig. S12).

Experiment 5: Excluding those proxy series (43 in number) that correlate negatively with the mean centennial anomalies of their near-neighbors.

Results: This experiment results in no changes in either the overall coverage or the anomaly patterns observed except for a notable cooler MWP in southwestern North America and warmer conditions in China in the 14th century (Fig. S13).

In conclusion, the different experiments show that the general spatial patterns found are robust, although the exclusion of tree-ring data does somewhat suppress the 20th century warmth. As might be expected, any selection criteria that reduce the number of proxies decrease the spatial coverage.

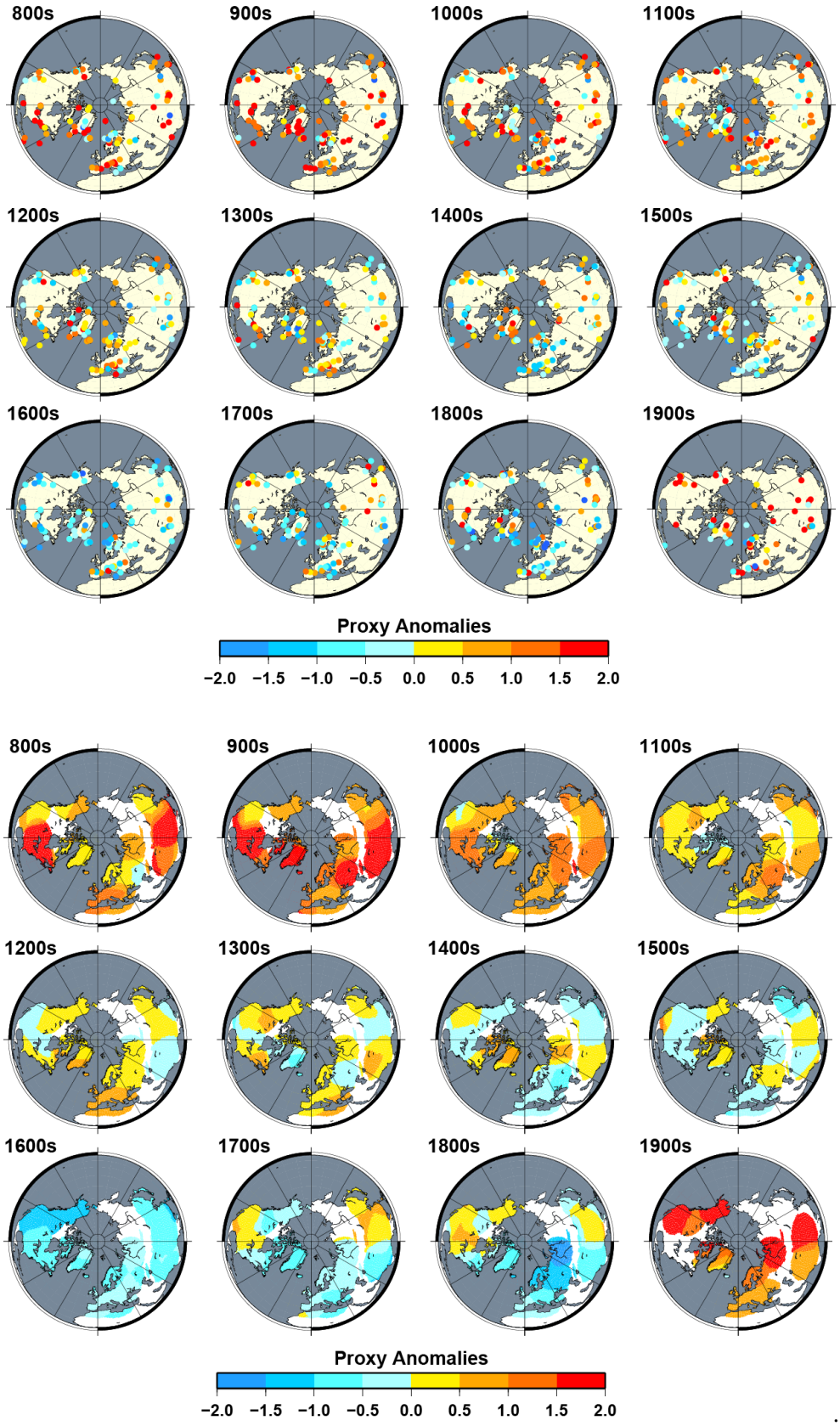

Fig. S1. Analysis excluding documentary records. Upper panel: Raw, centennial, proxy anomaly values. Anomalies are shown relative to the centennial mean and standard deviation over the 11th–19th centuries. Lower panel: Gridded, weighted, values for the same data. The color scale in both panels is truncated at –2 and 2.

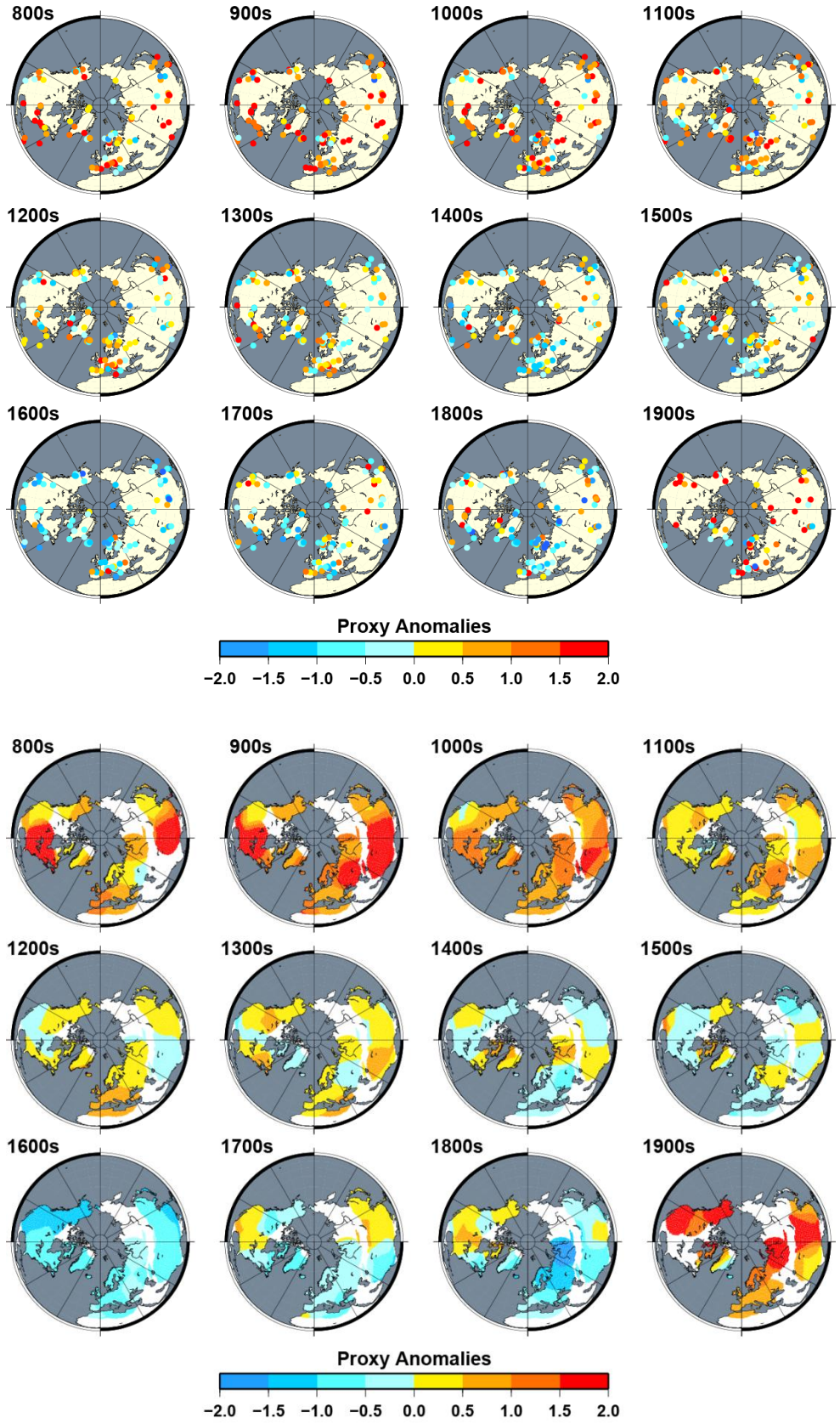

Fig. S2. Analysis excluding ice-core records. Upper panel: Raw, centennial, proxy anomaly values. Anomalies are shown relative to the centennial mean and standard deviation over the 11th–19th centuries. Lower panel: Gridded, weighted, values for the same data. The color scale in both panels is truncated at –2 and 2.

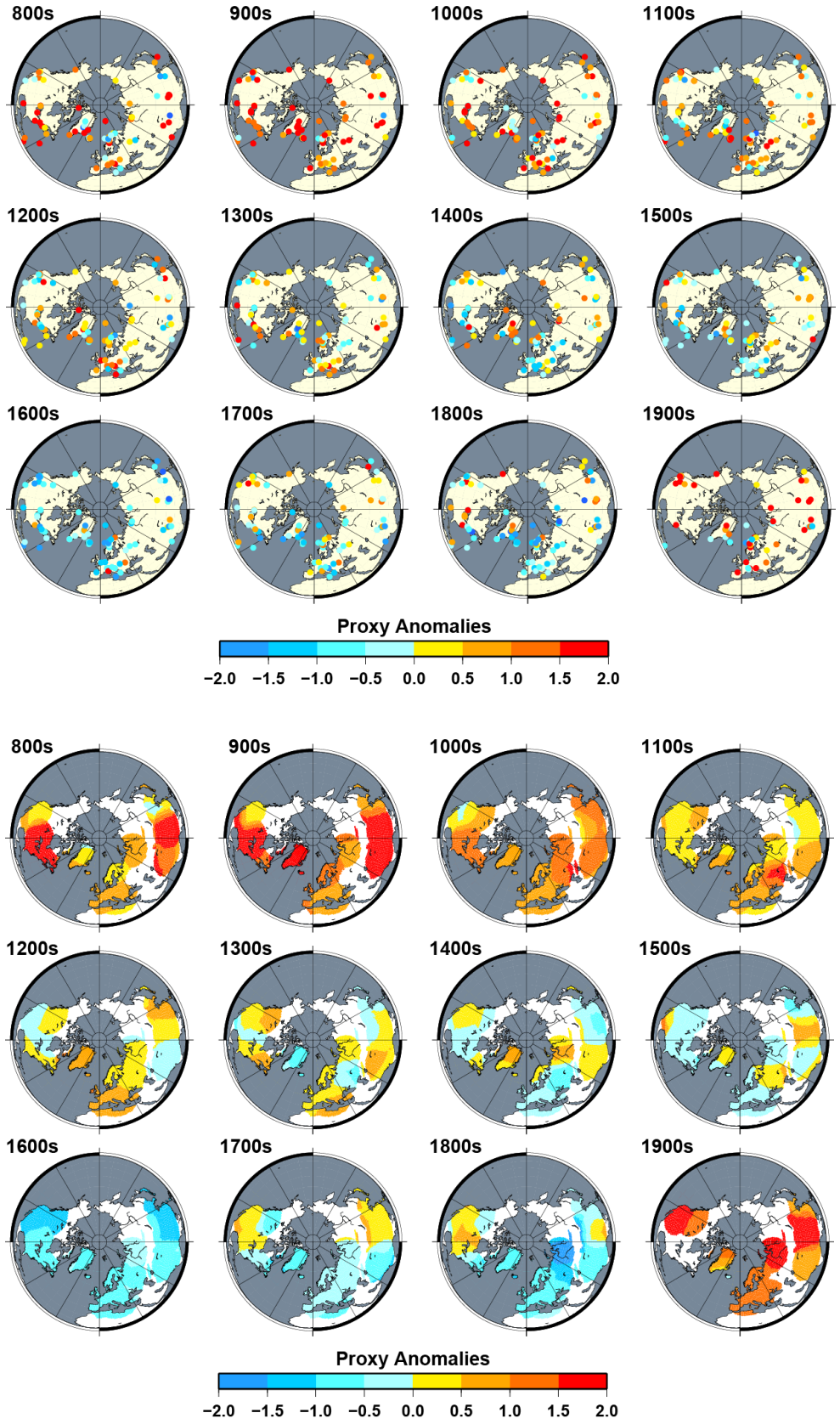

Fig. S3. Analysis excluding lake sediment records. Upper panel: Raw, centennial, proxy anomaly values. Anomalies are shown relative to the centennial mean and standard deviation over the 11th–19th centuries. Lower panel: Gridded, weighted, values for the same data. The color scale in both panels is truncated at –2 and 2.

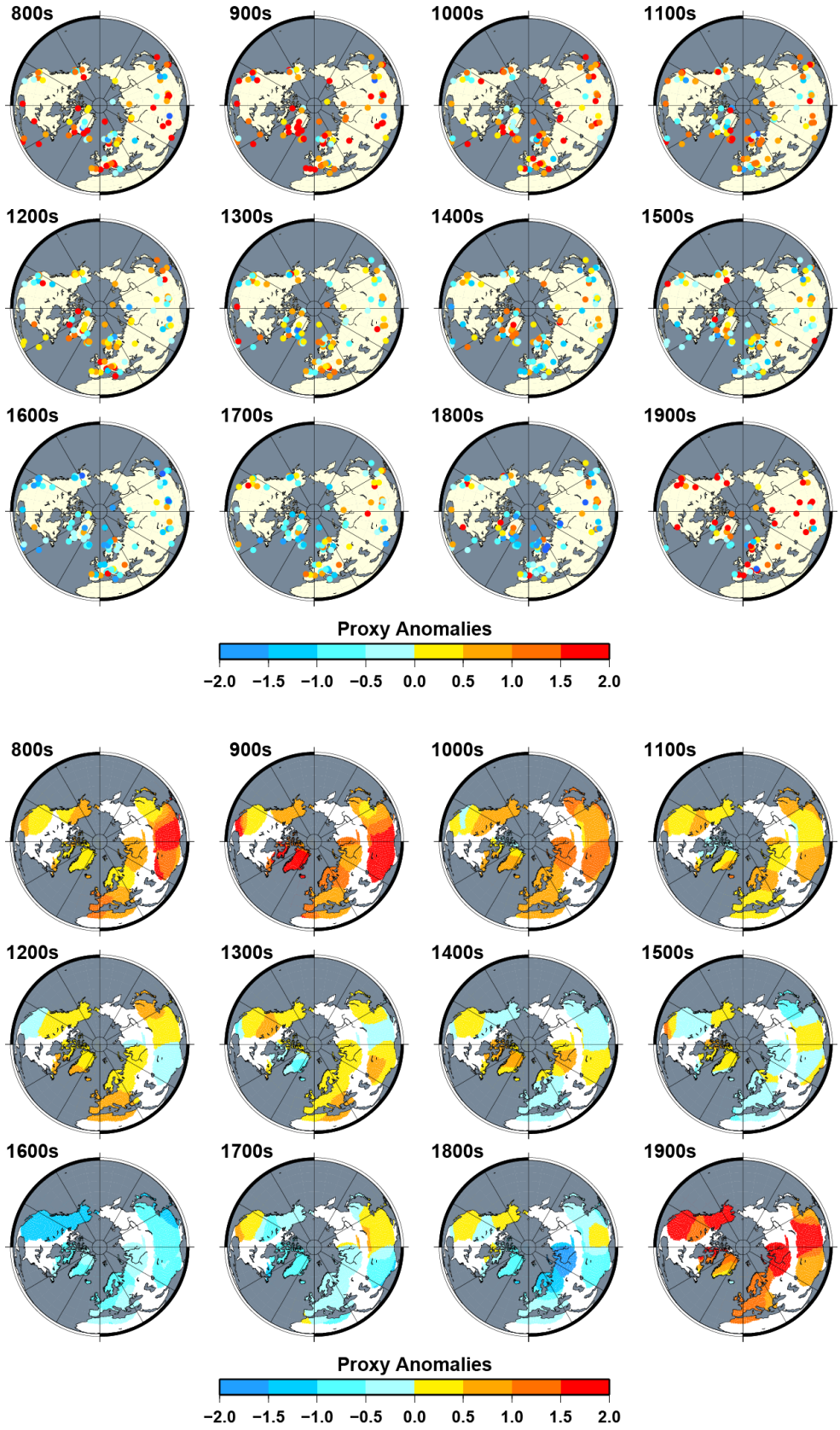

Fig. S4. Analysis excluding pollen records. Upper panel: Raw, centennial, proxy anomaly values. Anomalies are shown relative to the centennial mean and standard deviation over the 11th–19th centuries. Lower panel: Gridded, weighted, values for the same data. The color scale in both panels is truncated at –2 and 2.

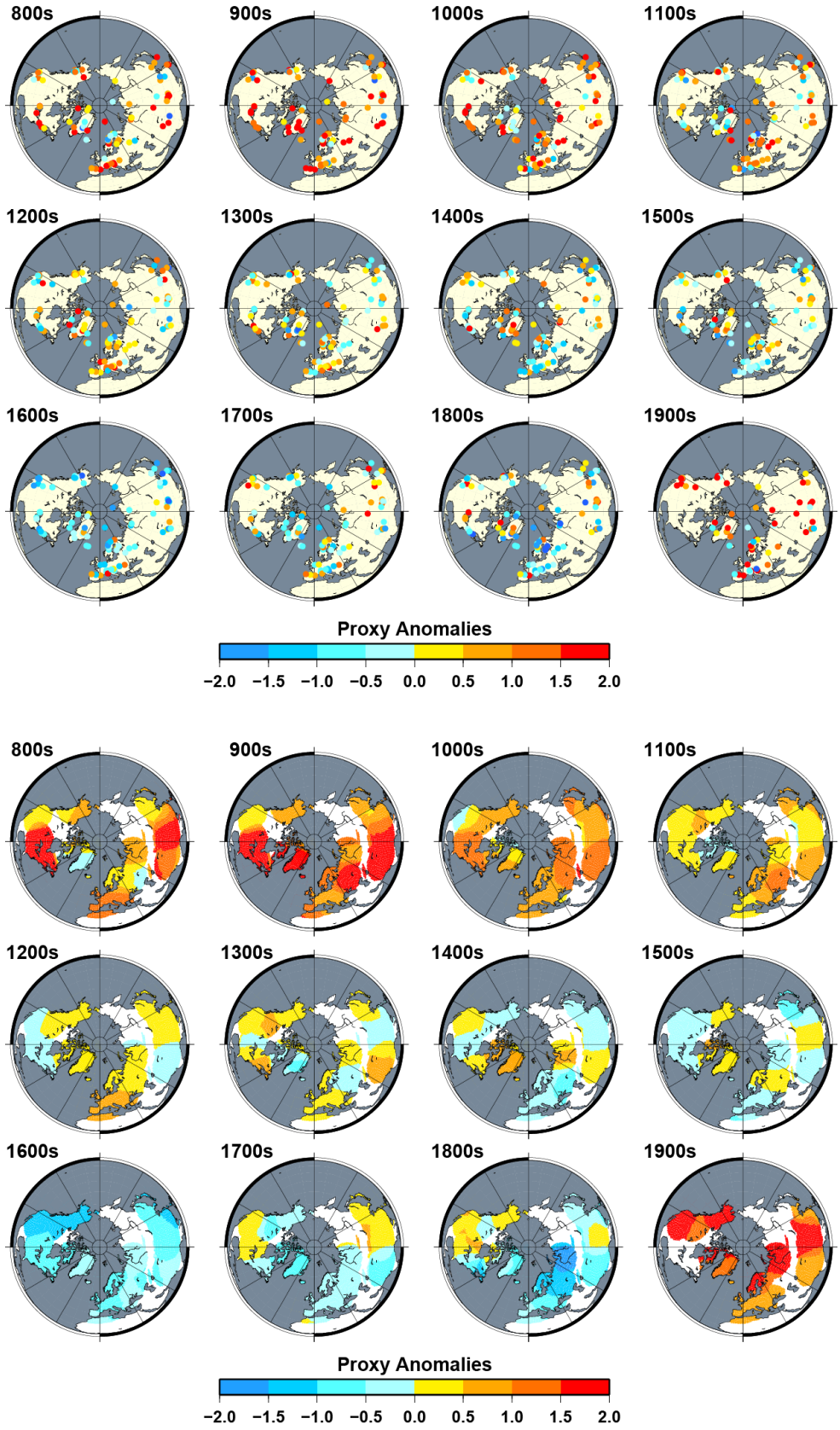

Fig. S5. Analysis excluding sea sediment records. Upper panel: Raw, centennial, proxy anomaly values. Anomalies are shown relative to the centennial mean and standard deviation over the 11th–19th centuries. Lower panel: Gridded, weighted, values for the same data. The color scale in both panels is truncated at –2 and 2.

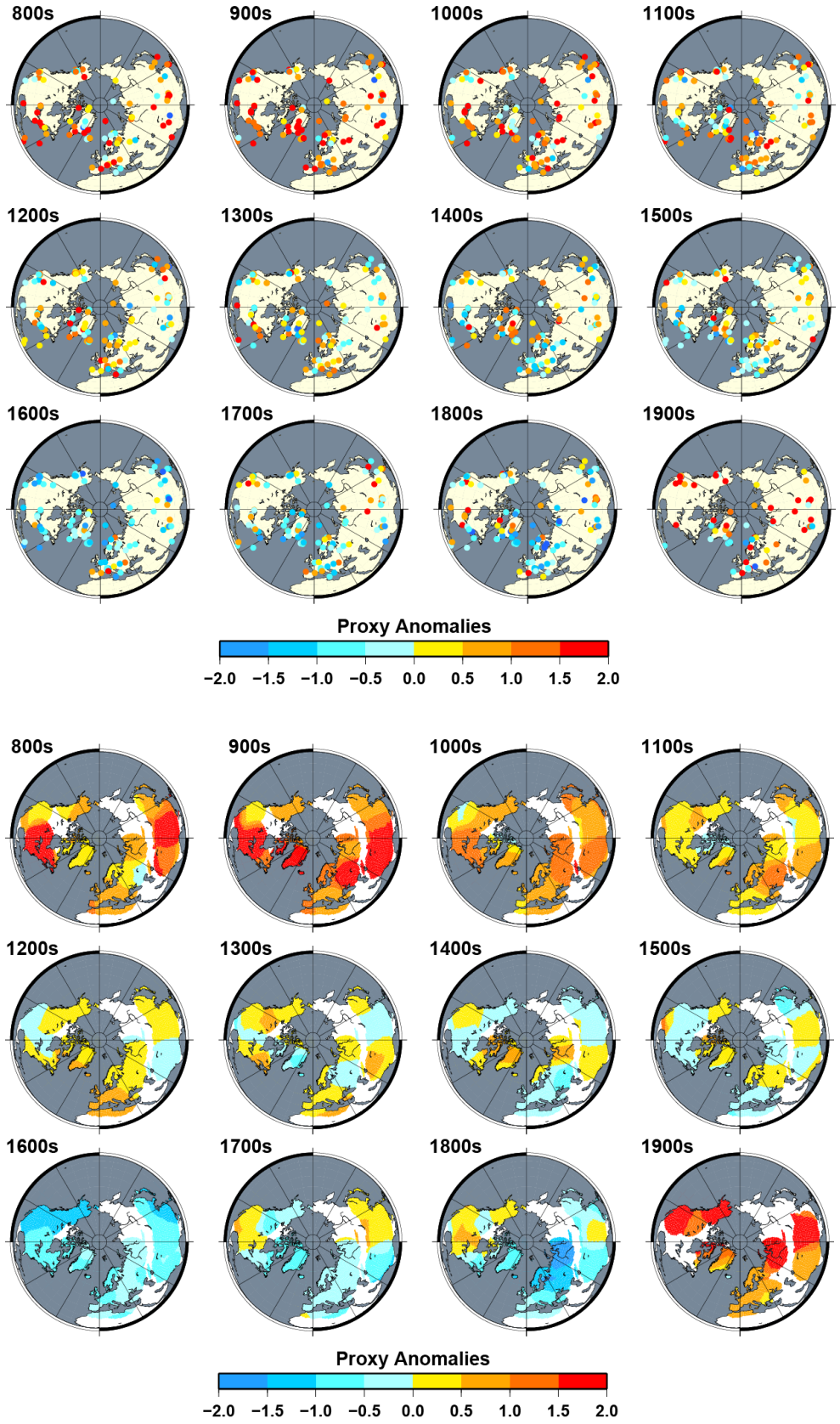

Fig. S6. Analysis excluding speleothem records. Upper panel: Raw, centennial, proxy anomaly values. Anomalies are shown relative to the centennial mean and standard deviation over the 11th–19th centuries. Lower panel: Gridded, weighted, values for the same data. The color scale in both panels is truncated at –2 and 2.

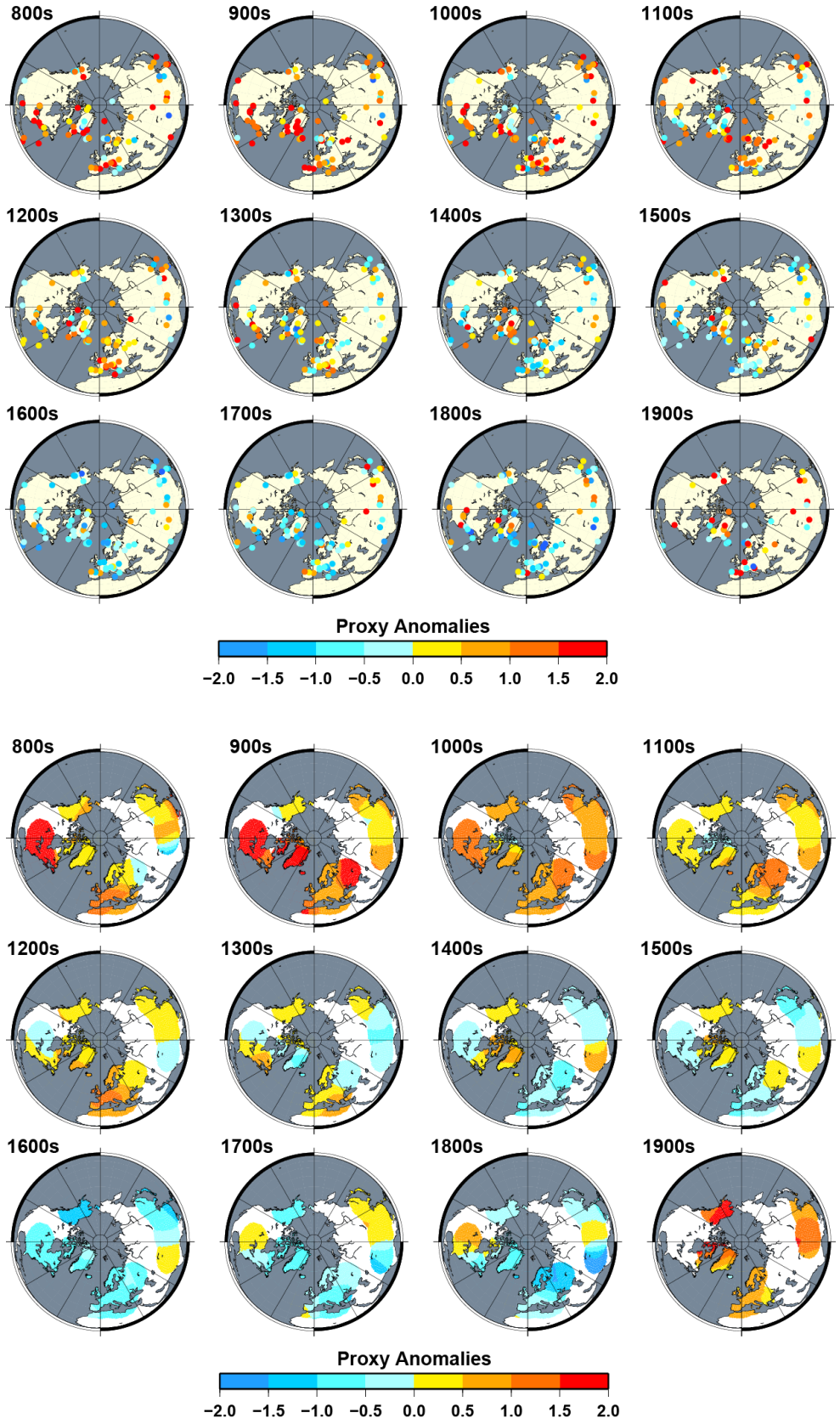

Fig. S7. Analysis excluding tree-ring records. Upper panel: Raw, centennial, proxy anomaly values. Anomalies are shown relative to the centennial mean and standard deviation over the 11th–19th centuries. Lower panel: Gridded, weighted, values for the same data. The color scale in both panels is truncated at –2 and 2.

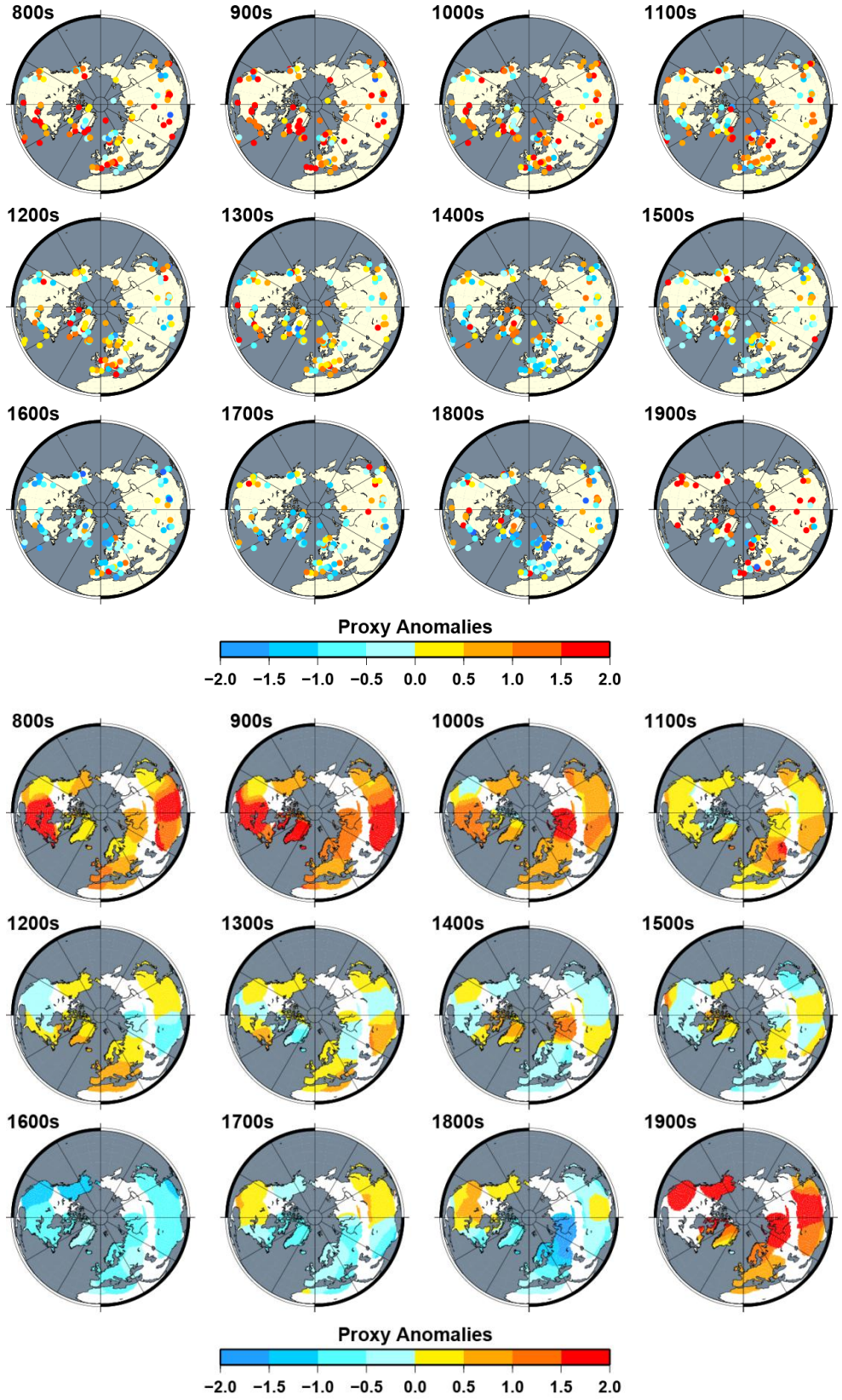

Fig. S8. Analysis excluding other records. Upper panel: Raw, centennial, proxy anomaly values. Anomalies are shown relative to the centennial mean and standard deviation over the 11th–19th centuries. Lower panel: Gridded, weighted, values for the same data. The color scale in both panels is truncated at –2 and 2.

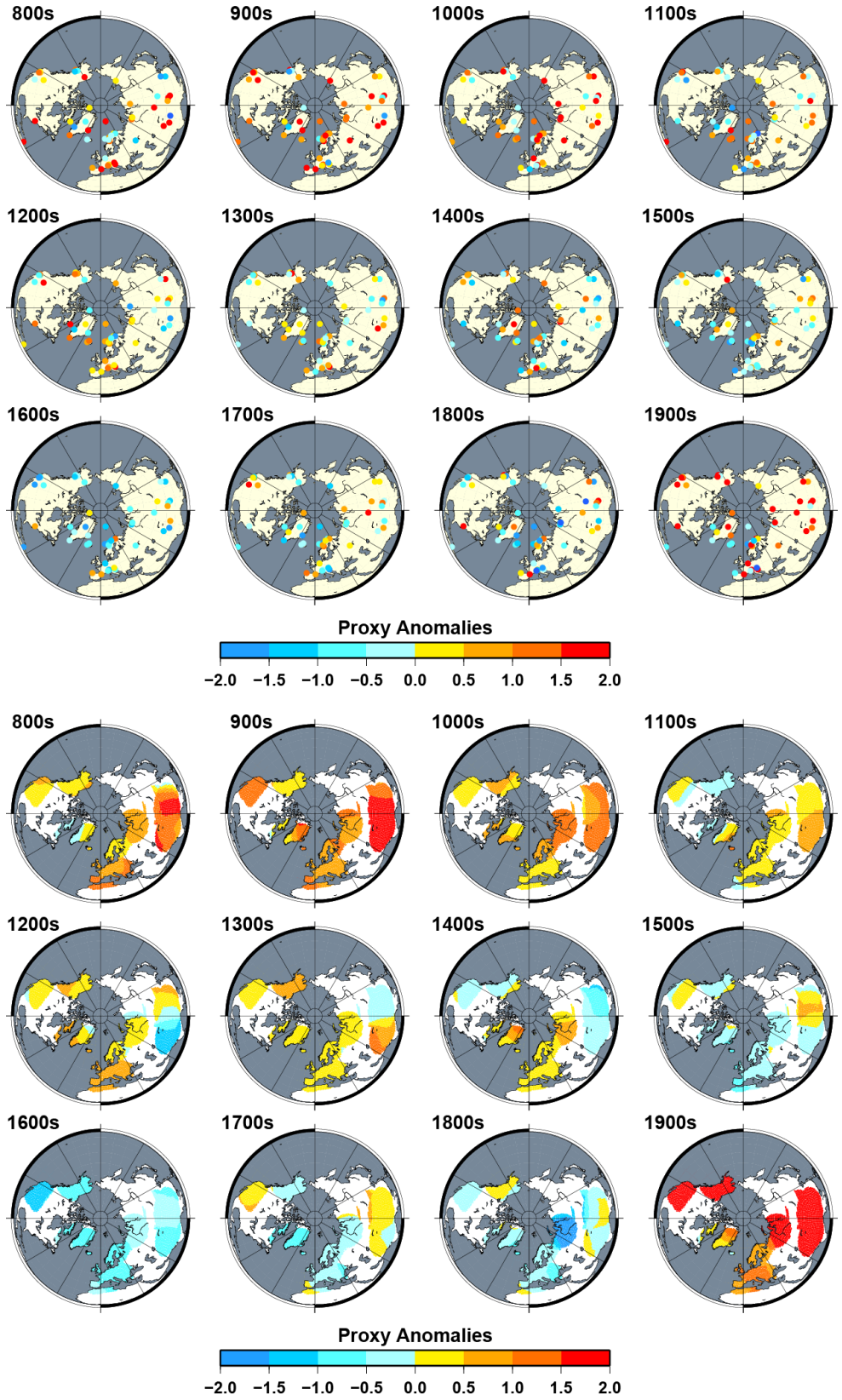

Fig. S9. Analysis using only those proxies that extend back beyond AD 816 and post AD 1984. Upper panel: Raw, centennial, proxy anomaly values. Anomalies are shown relative to the centennial mean and standard deviation over the 11th–19th centuries. Lower panel: Gridded, weighted, values for the same data. The color scale in both panels is truncated at –2 and 2.

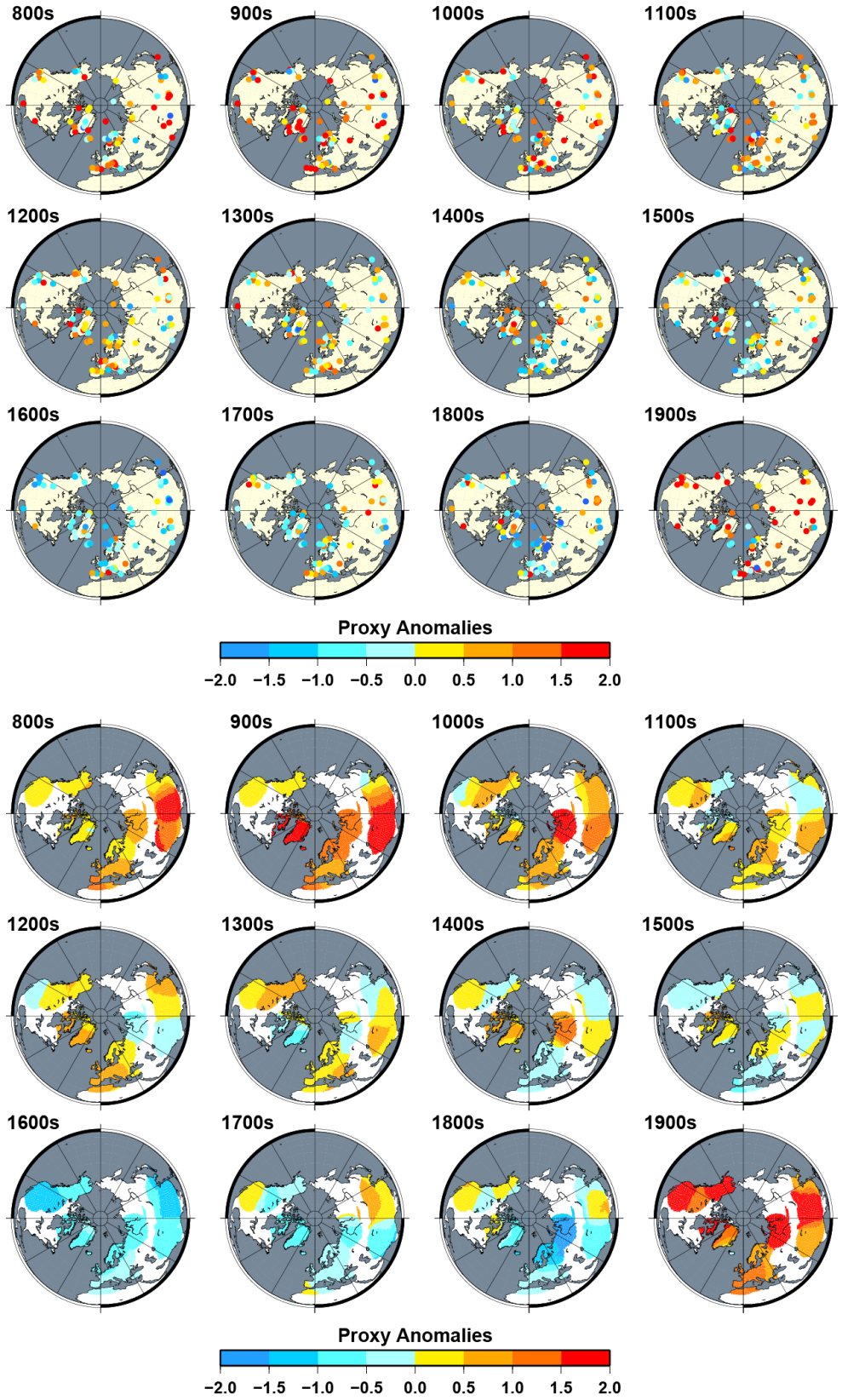

Fig. S10. Analysis using only those proxies that have at least 4 for data points a century. Upper panel: Raw, centennial, proxy anomaly values. Anomalies are shown relative to the centennial mean and standard deviation over the 11th–19th centuries. Lower panel: Gridded, weighted, values for the same data. The color scale in both panels is truncated at –2 and 2.

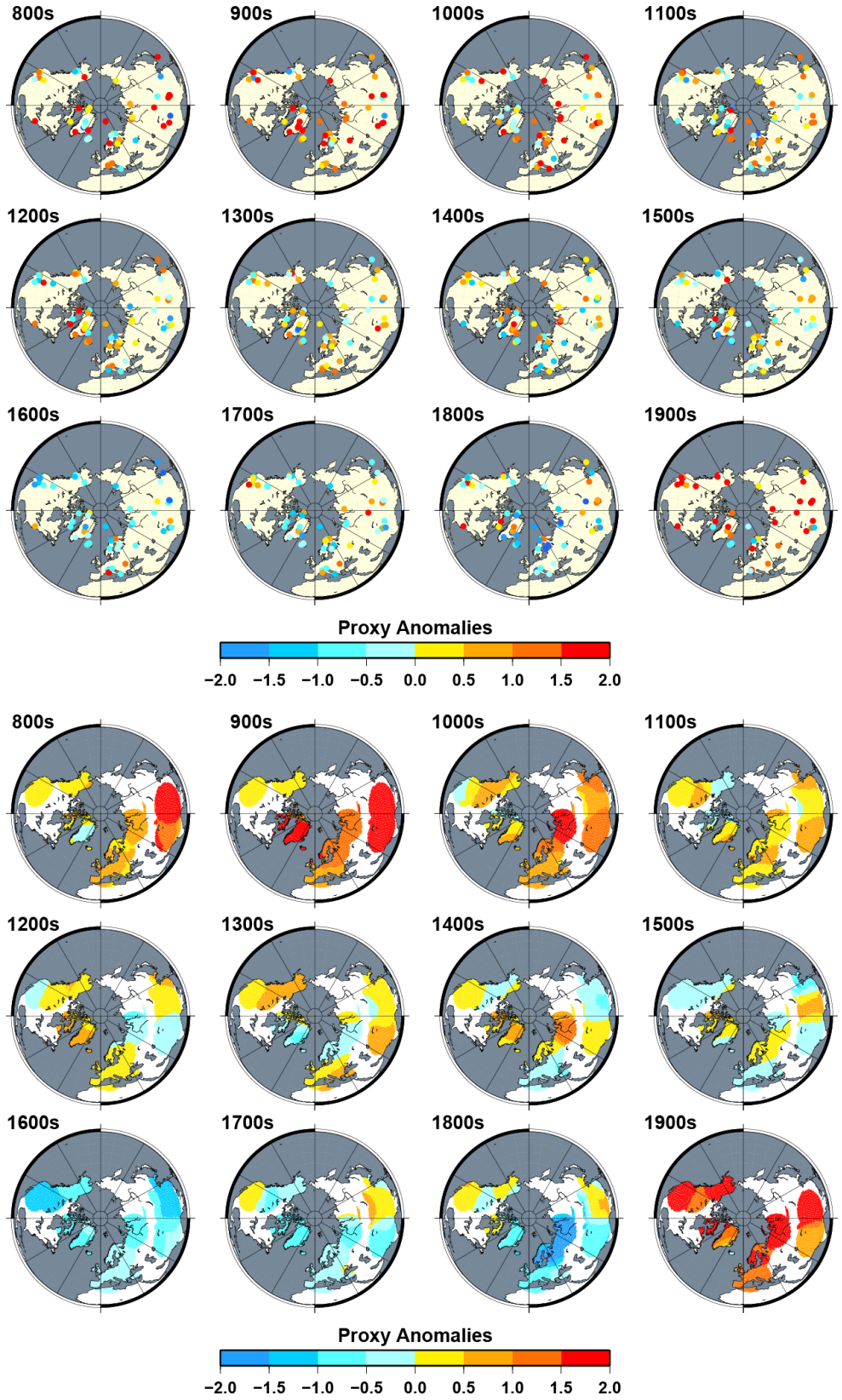

Fig. S11. Analysis using only those proxies that have at least 10 for data points a century. Upper panel: Raw, centennial, proxy anomaly values. Anomalies are shown relative to the centennial mean and standard deviation over the 11th–19th centuries. Lower panel: Gridded, weighted, values for the same data. The color scale in both panels is truncated at –2 and 2.

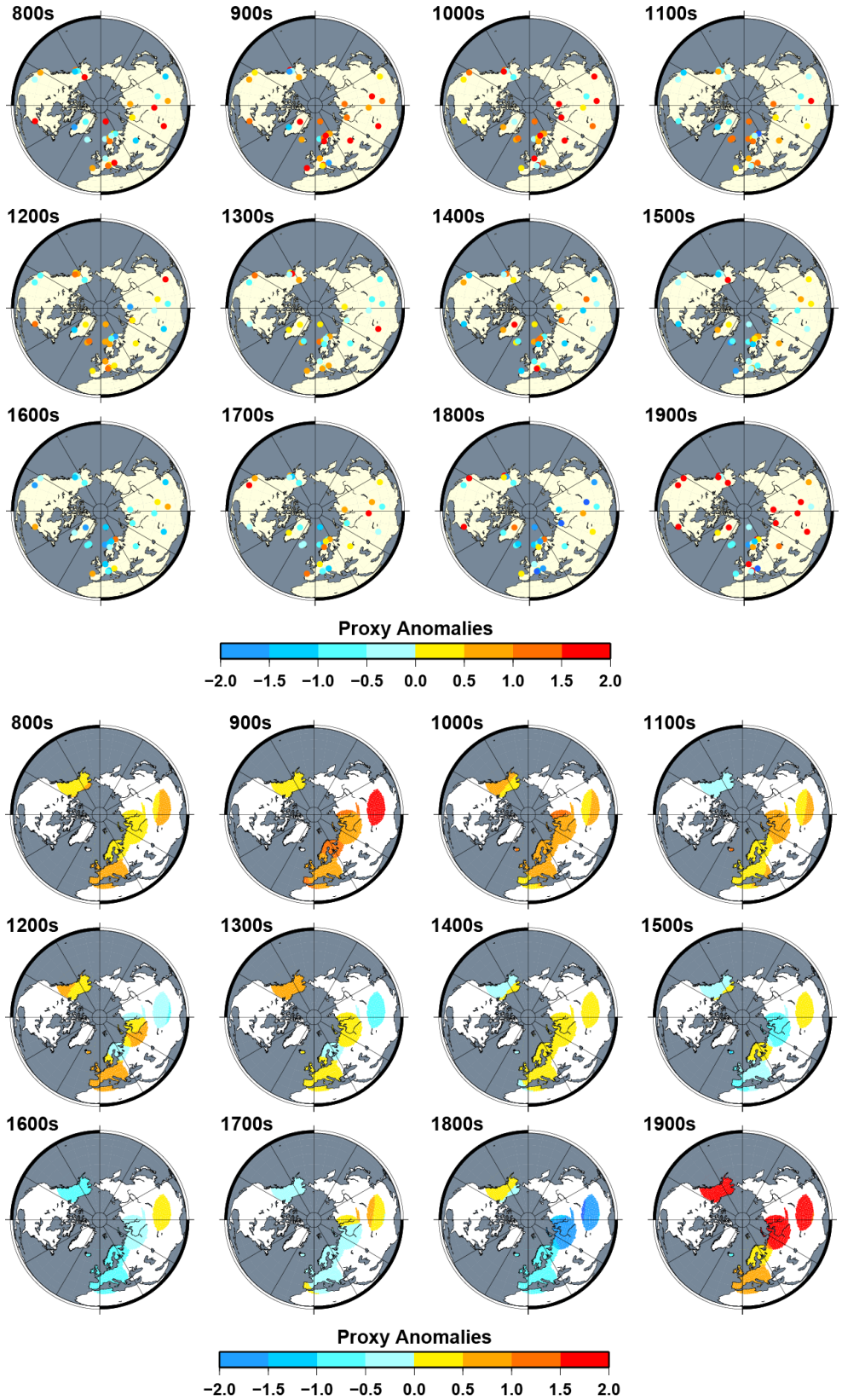

Fig. S12. Analysis using proxies extending at least up to AD 1995. Upper panel: Raw, centennial, proxy anomaly values. Anomalies are shown relative to the centennial mean and standard deviation over the 11th–19th centuries. Lower panel: Gridded, weighted, values for the same data. The color scale in both panels is truncated at –2 and 2.

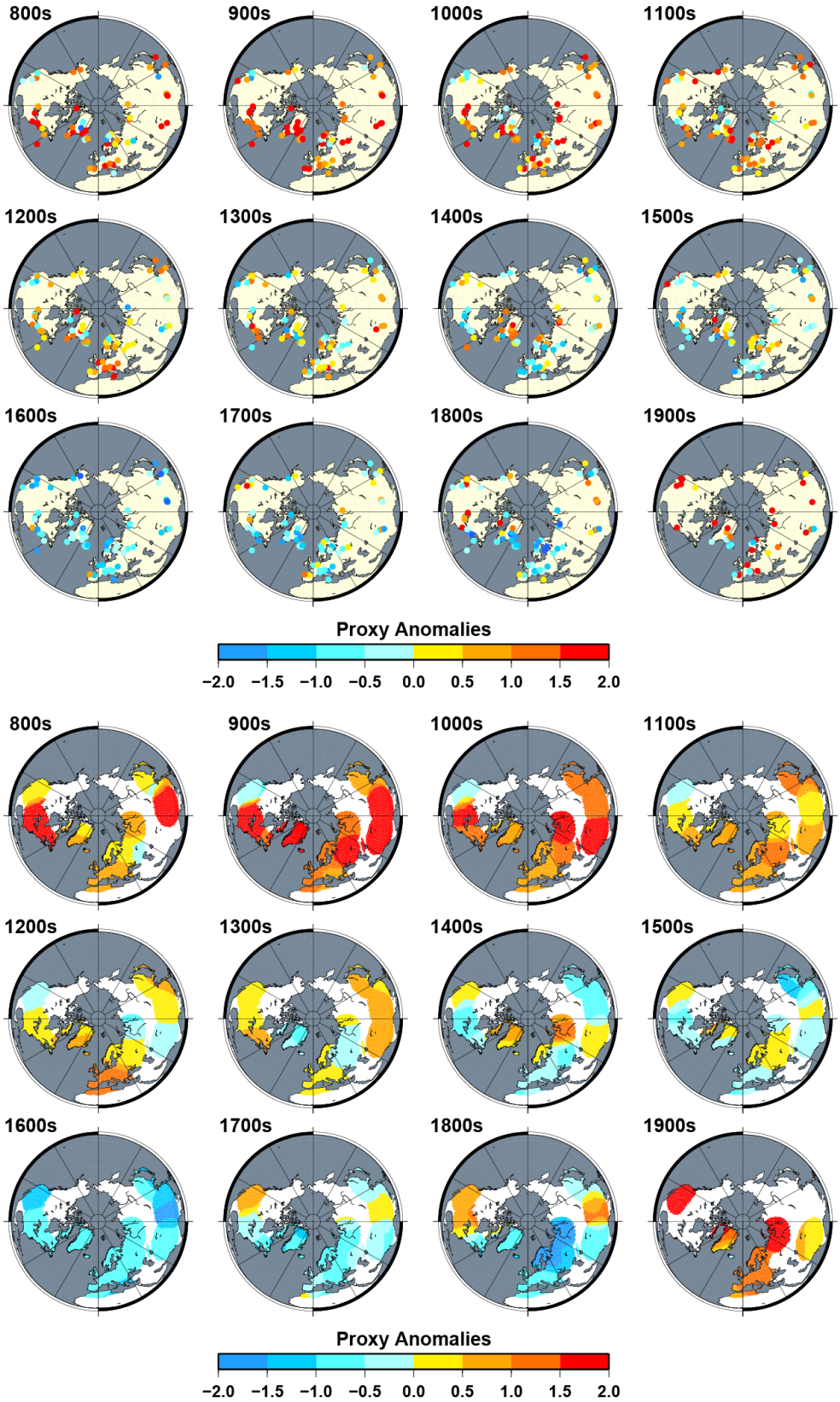

Fig. S13. Gridded spatially averaged and interpolated centennial temperature proxy anomalies excluding those fourteen proxy series that correlate negatively with the mean time-series of their within-search-radius neighbors. The color scale in both panels is truncated at –2 and 2.