## S1: Supplementary materials

**Table S1.** Pearson correlation coefficient between the observed tree-ring width (TRW) time series and the tree-ring index time series simulated by the regression model (Sect. 2.4.2) over 1950-2000 (calibration period) and 1901-1949 (verification period) at the 21 TRW sites of the PAGES2k databases (PAGES 2k Consortium, 2013, 2017). The site names are from the PAGES2k database: *Aus* for Tasmanian or New Zealand sites; *SAm* for South American sites. Asterisks stand for significant correlation coefficients at the 95% confidence level.

| Site | Calibration | Verification |
|------|-------------|--------------|
| Aus_001 | 0.42* | -0.09 |
| Aus_002 | 0.31* | -0.08 |
| Aus_004 | 0.24 | 0.15 |
| Aus_005 | 0.52* | -0.03 |
| Aus_007 | 0.65* | 0.35* |
| Aus_009 | 0.43* | -0.06 |
| Aus_030 | 0.16 | 0.31* |
| Aus_031 | 0.25 | -0.05 |
| SAm_006 | 0.65 | 0.01 |
| SAm_024 | 0.09 | 0.03 |
| SAm_025 | 030* | 0.50* |
| SAm_029 | 0.25 | 0.12 |
| SAm_9 | 0.29* | -0.06 |
| SAm_10 | 0.17 | 0.07 |
| SAm_11 | 0.57* | 0.22 |
| SAm_12 | 0.31* | 0.09 |
| SAm_15 | 0.18 | -0.04 |
| SAm_16 | 0.18 | 0.21 |
| SAm_17 | 0.20 | 0.22 |
| SAm_18 | 0.09 | -0.07 |
| SAm_19 | 0.13 | -0.15 |
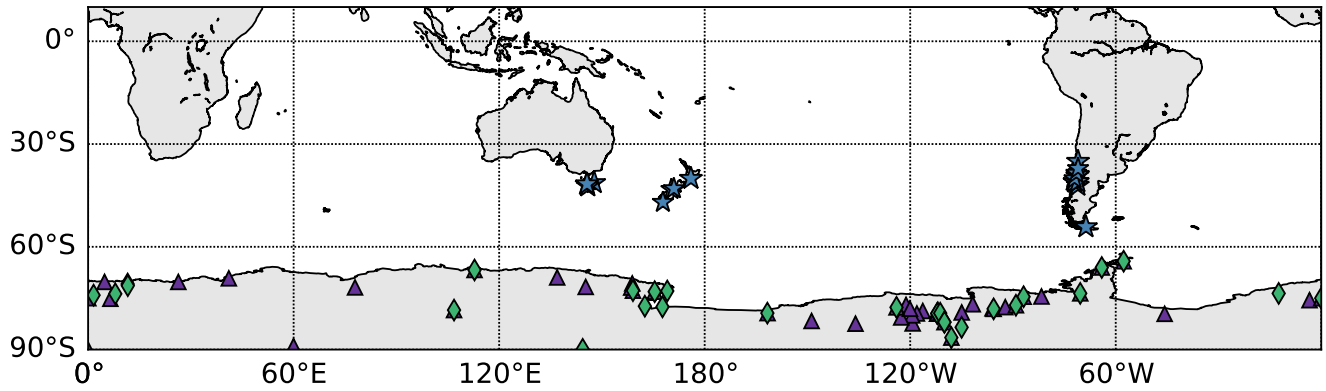
**Figure S1.** Location of the 21 tree-ring width (TRW) records (blue stars) from the PAGES2k databases (PAGES 2k Consortium, 2013, 2017); the 49 ice core snow accumulation records (purple triangles) from Thomas et al. (2017) and Medley et al. (2018); and the 29 $\delta^{18}O$ records (green diamonds) from Stenni et al. (2017) (Sect. 2.3). Background map from Hunter (2007).
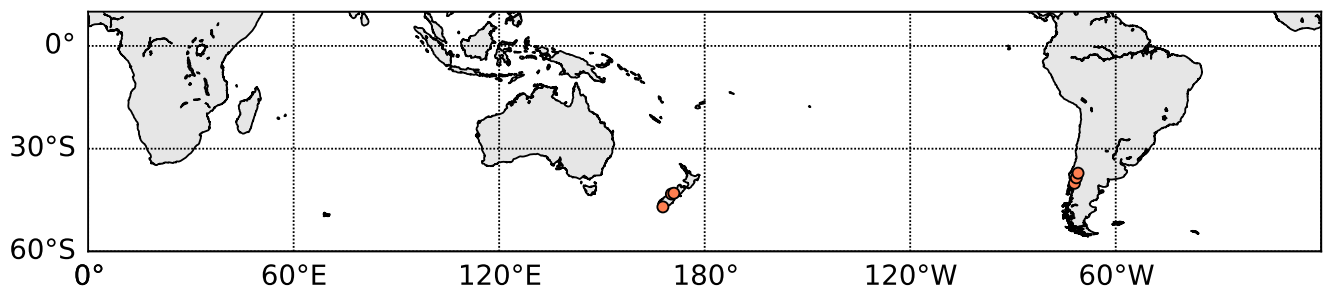
**Figure S2.** Location of the six tree-ring width (TRW) records (orange circles) from the PAGES2k databases (PAGES 2k Consortium, 2013, 2017) assimilated with the MAIDEN model calibrated over the 1950-2000 CE time period (see Sect. 2.4.1 for more details). Background map from Hunter (2007).
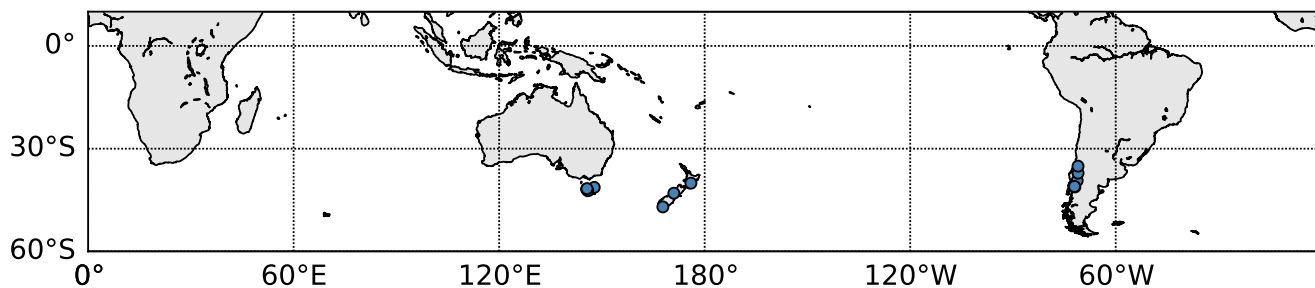
**Figure S3.** Location of the 12 tree-ring width (TRW) records (blue circles) from the PAGES2k databases (PAGES 2k Consortium, 2013, 2017) assimilated with the regression-based model calibrated over the 1901-2000 CE time period (see Sect. 2.4.2 for more details). Background map from Hunter (2007).
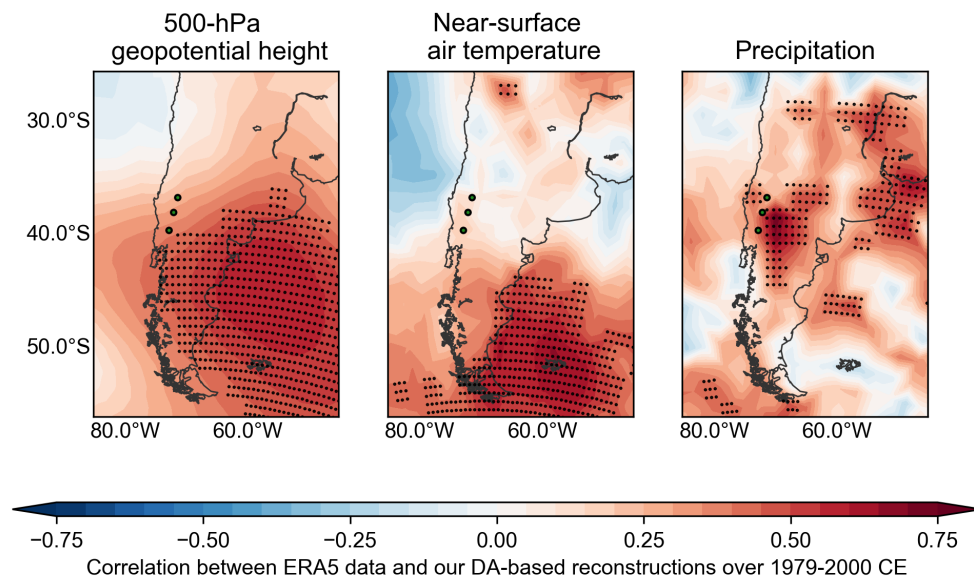
**Figure S4.** Pearson correlation coefficient between the reconstructed and ERA5 geopotential height at 500 hPa, near-surface air temperature or cumulative precipitation in South America over 1979-2000 CE for the TIC-MDN experiment (see Sect. 3 and Table 1 for details on the experiment). The green dots indicate the localization of the assimilated tree-ring width records. The black dots indicate a significant correlation coefficient at the 95% confidence level.
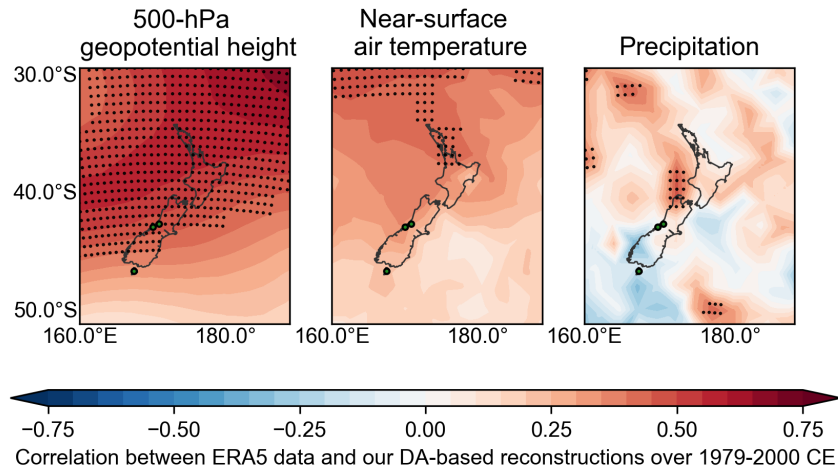
**Figure S5.** Pearson correlation coefficient between the reconstructed and ERA5 geopotential height at 500 hPa, near-surface air temperature or cumulative precipitation in New Zealand over 1979-2000 CE for the TIC-MDN experiment (see Sect. 3 and Table 1 for details on the experiment). The green dots indicate the localization of the assimilated tree-ring width records. The black dots indicate a significant correlation coefficient at the 95% confidence level.
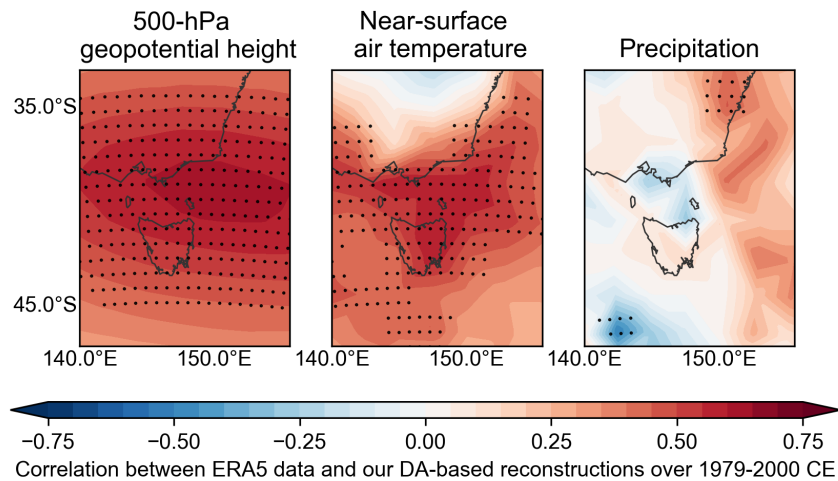
**Figure S6.** Pearson correlation coefficient between the reconstructed and ERA5 geopotential height at 500 hPa, near-surface air temperature or cumulative precipitation in Tasmania over 1979-2000 CE for the TIC-MDN experiment (see Sect. 3 and Table 1 for details on the experiment). The green dots indicate the localization of the assimilated tree-ring width records. The black dots indicate a significant correlation coefficient at the 95% confidence level.
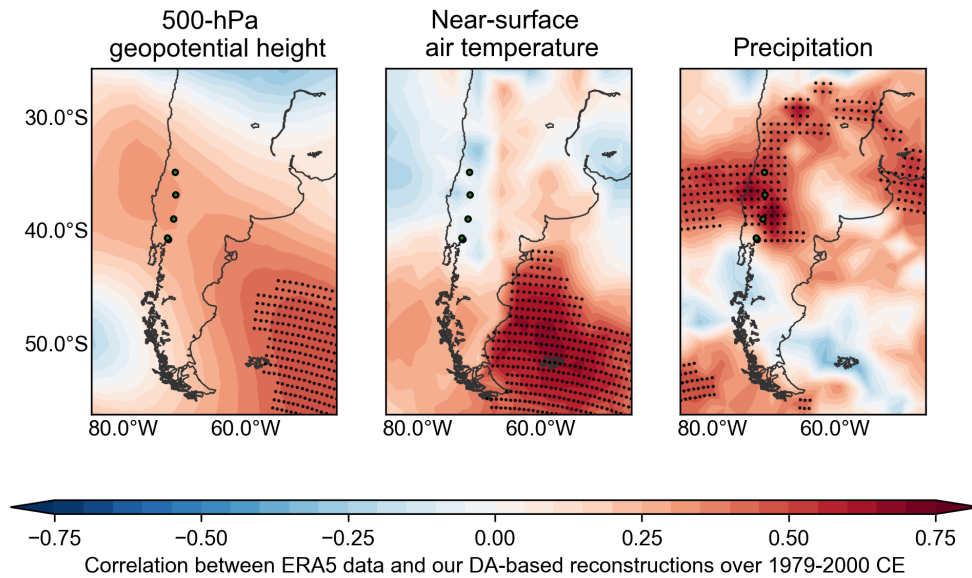
**Figure S7.** Pearson correlation coefficient between the reconstructed and ERA5 geopotential height at 500 hPa, near-surface air temperature or cumulative precipitation in South America over 1979-2000 CE for the TIC-reg experiment (see Sect. 3 and Table 1 for details on the experiment). The green dots indicate the localization of the assimilated tree-ring width records. The black dots indicate a significant correlation coefficient at the 95% confidence level.
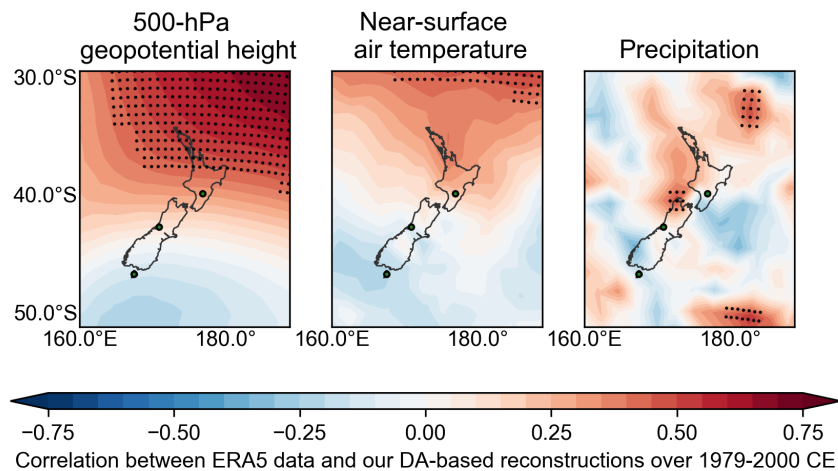
**Figure S8.** Pearson correlation coefficient between the reconstructed and ERA5 geopotential height at 500 hPa, near-surface air temperature or cumulative precipitation in New Zealand over 1979-2000 CE for the TIC-reg experiment (see Sect. 3 and Table 1 for details on the experiment). The green dots indicate the localization of the assimilated tree-ring width records. The black dots indicate a significant correlation coefficient at the 95% confidence level.
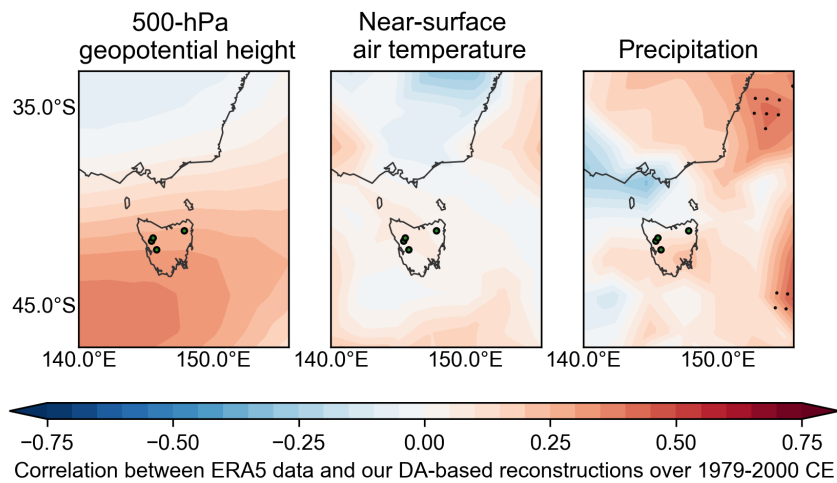
**Figure S9.** Pearson correlation coefficient between the reconstructed and ERA5 geopotential height at 500 hPa, near-surface air temperature or cumulative precipitation in Tasmania over 1979-2000 CE for the TIC-reg experiment (see Sect. 3 and Table 1 for details on the experiment). The green dots indicate the localization of the assimilated tree-ring width records. The black dots indicate a significant correlation coefficient at the 95% confidence level.
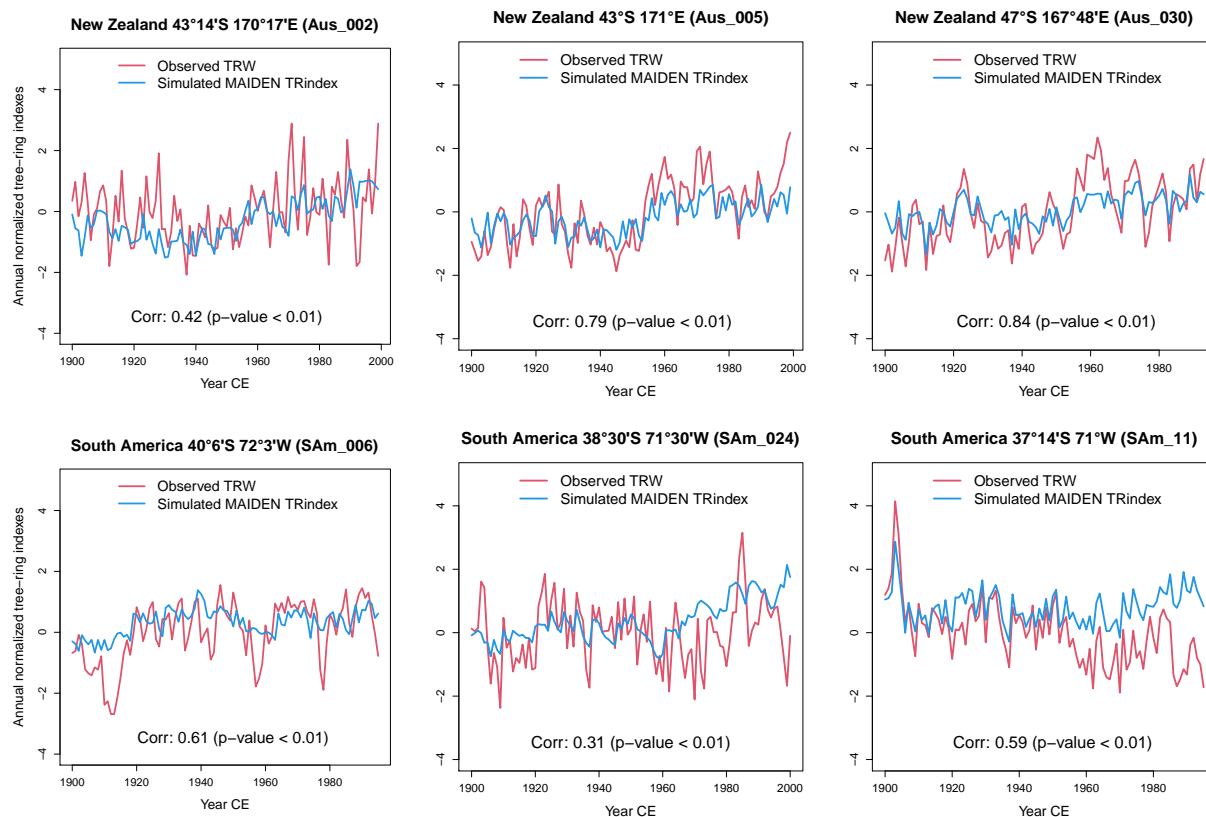
**Figure S10.** Observed tree-ring width and simulated tree-ring index by MAIDEN over 1900-2000 CE at the six assimilated tree-ring width sites (Sect. 2.4.1). Pearson correlation coefficient (Corr) between observed and simulated tree-ring index and associated p-value. The observations are normalized relative to 1900-2000 CE. The simulations are normalized relative to 1900-2000 CE using the mean and the standard deviation of the reference run of MAIDEN with the iCESM1 data used in the data assimilation procedure (Sect. 2.4.1). The TIC-MDN reanalysis is used to run MAIDEN (see Sect. 3 for details on the data assimilation experiment).
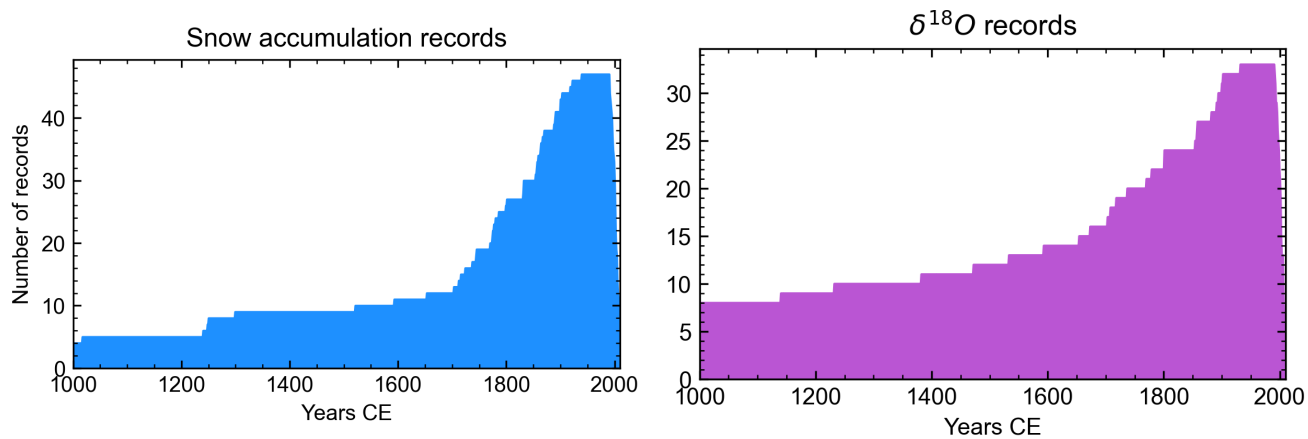
**Figure S11.** Number of snow accumulation and $\delta^{18}$O records used in this study (Sect. 2.3.2) over 1000-2000 CE. Figures from Dalaiden et al. (2021).
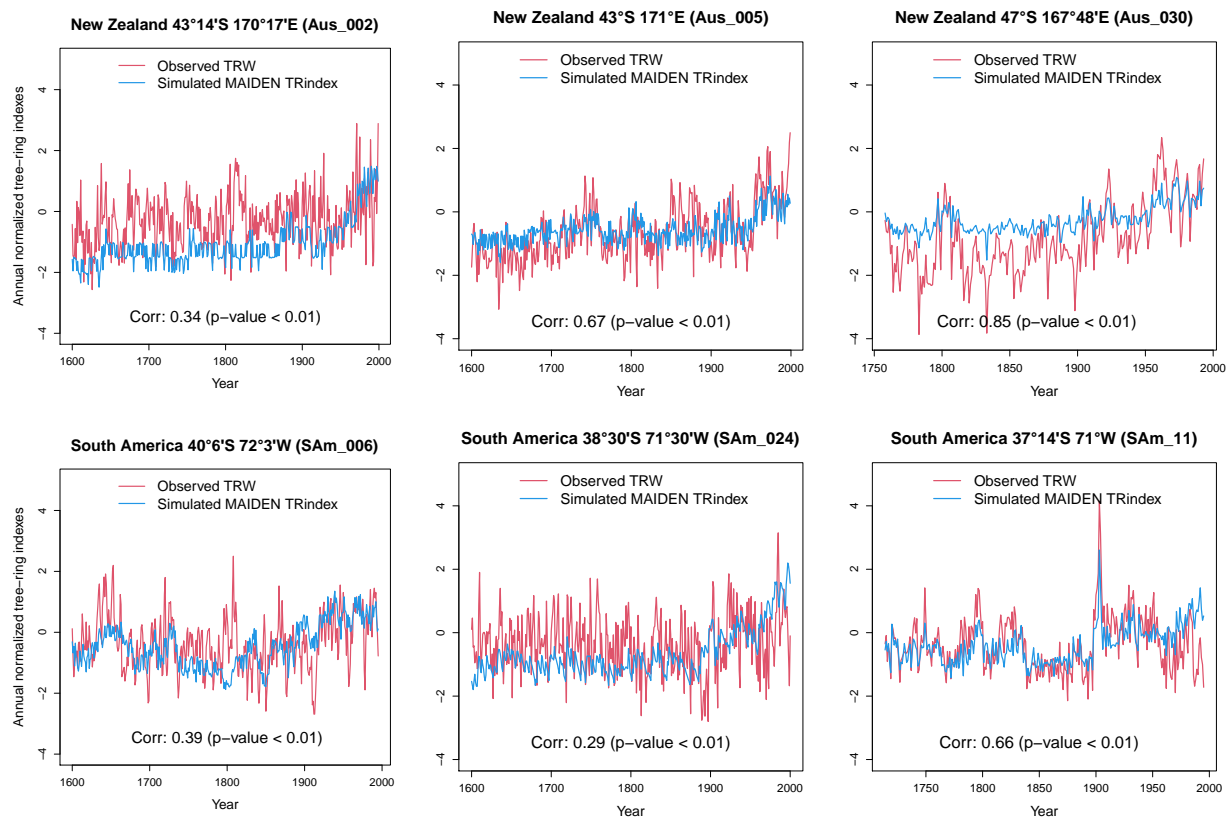
**Figure S12.** Observed tree-ring width and simulated tree-ring index by MAIDEN over 1600-2000 CE at the six assimilated tree-ring width sites (Sect. 2.4.1). Pearson correlation coefficient (Corr) between observed and simulated tree-ring index and associated p-value. The observations are normalized relative to 1900-2000 CE. The simulations are normalized relative to 1900-2000 CE using the mean and the standard deviation of the reference run of MAIDEN with the iCESM1 data used in the data assimilation procedure (Sect. 2.4.1). The TIC-MDN reanalysis is used to run MAIDEN (see Sect. 3 for details on the data assimilation experiment).