Supplementary Information

for

Quantifying the contribution of forcing and three prominent modes of variability on historical climate

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Introduction

This document contains figures which support the findings made in the main paper by either exploring the sensitivity of the analyses to choices made or by illustrating points that could aid understanding of the material presented in the main paper.

Figures

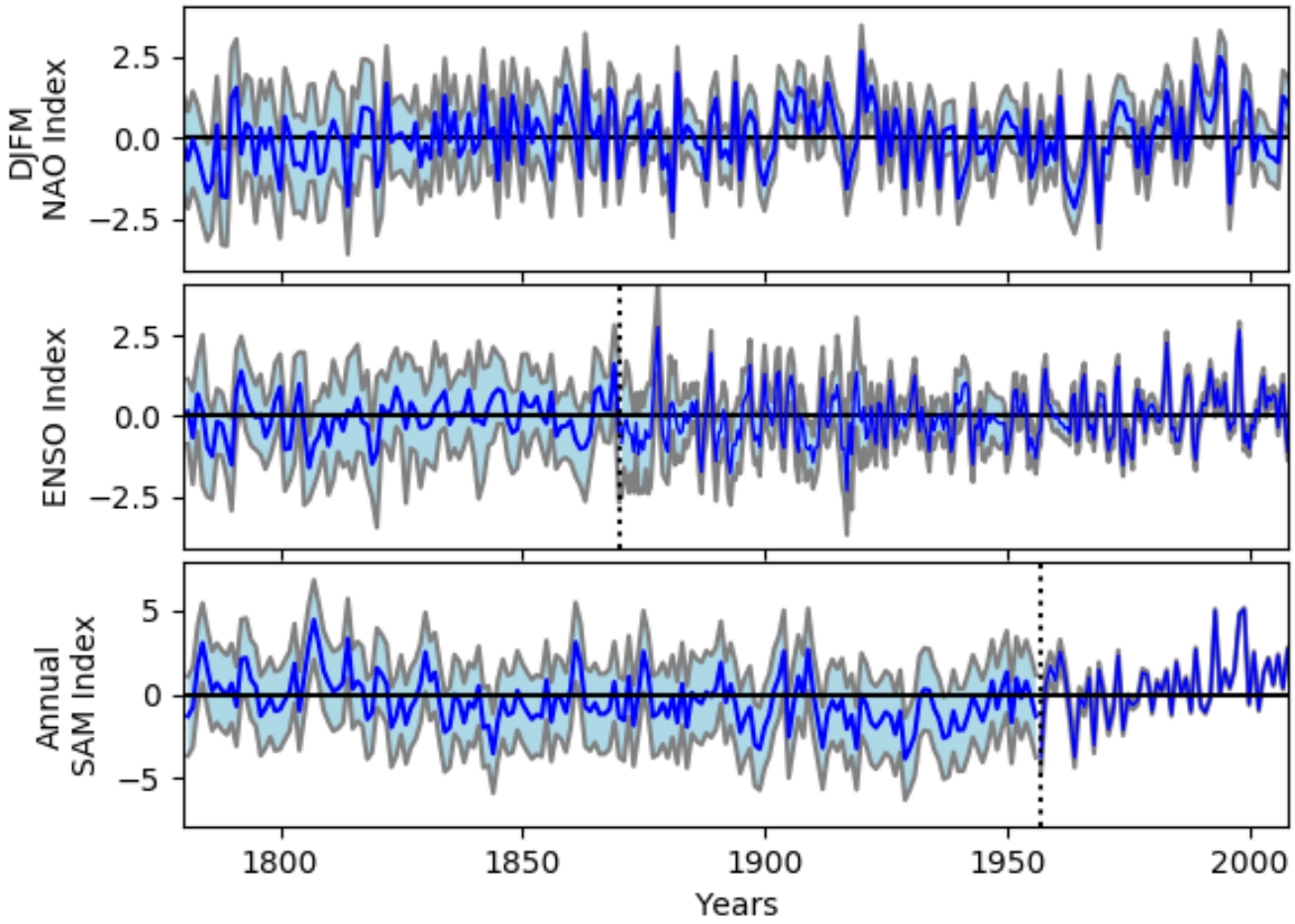

Figure S1 – The target metrics with uncertainties (2 standard deviations). Top panel – time-series *NAO (DJFM) mean 1781-2000 from* Luterbacher et al. (2001) *and 2001-2008 from 20CR* (Compo et al. 2011)*, uncertainty based on* Luterbacher et al. (2001)*;* ***Middle panel*** *ENSO index. 1781-1881 – (NDJF) mean of reconstructions of* Emile-Geay et al. (2013) *and* (Li et al. 2013) *with uncertainty range calculated from combining the two ranges in quadrature. 1882-2008*, two values per year: the mean from April to September and the mean of the index from October to March*, instrumental mean and uncertainty from HadSST2* (Kennedy et al. 2011a*,* Kennedy et al. 2011b). ***Bottom panel*** *SAM proxy reconstruction (1781-1956) mean and uncertainty range is* Abram et al. (2014). *1957-2008 mean Marshall Index* (Marshall 2003) *with uncertainties calculated from the spread of 20CR ensemble members.*

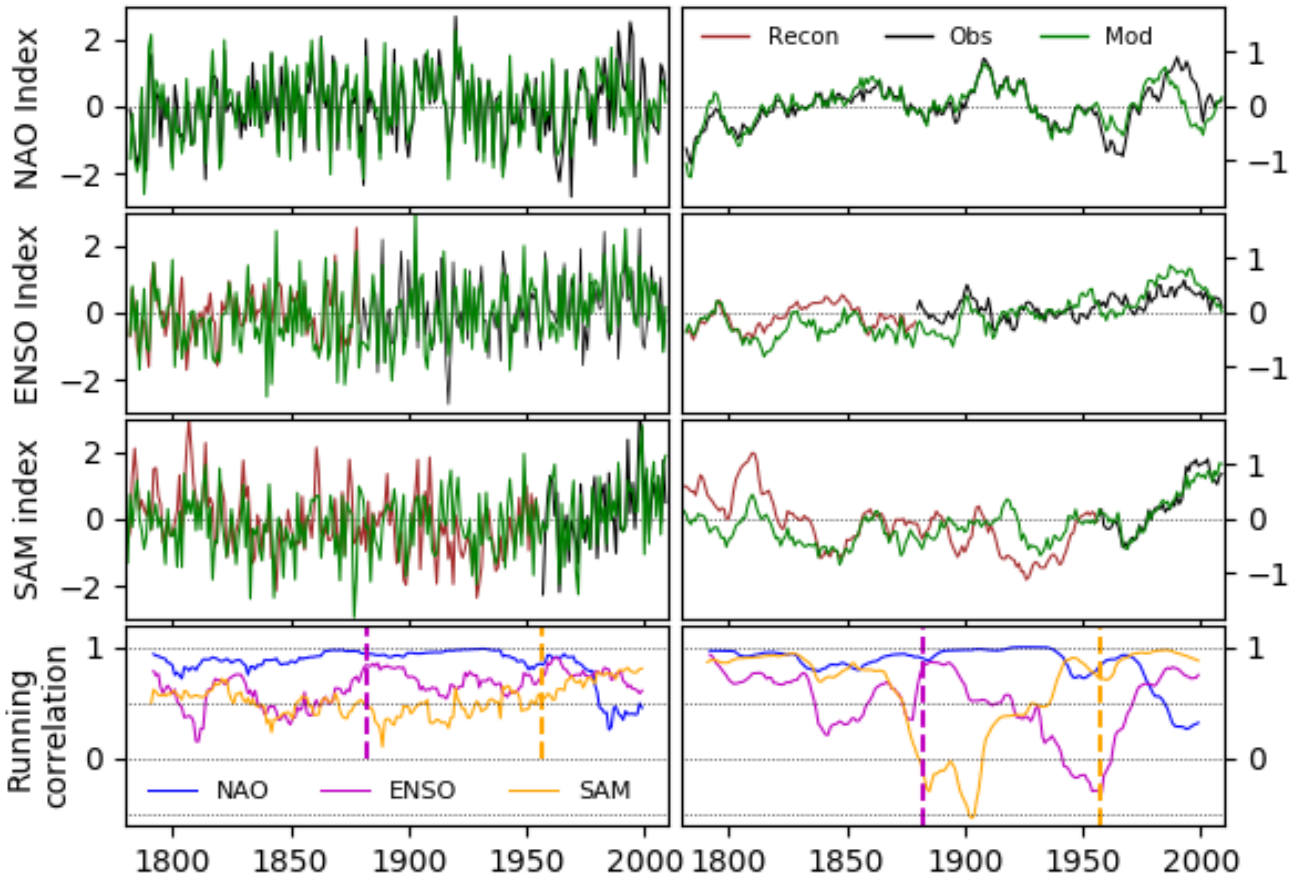

Figure S2 – Performance of filter (same as fig 3 except for continuous particle)– Top three panels – time-series of target metrics, *NAO (DJFM, climatology period 1782-2008), ENSO (NDJF, climatology period 1882-1992), SAM (Annual, climatology period 1957-1995) for the continuous particle analysis (green), Reconstruction (orange), Instrumental Observations (black). Left column - annual values, right column – annual values smoothed by an 11 year running mean. Bottom panel shows, left – running 20- year correlation for the annual value, right – 40-year correlations for the smoothed values, vertical dashed line show the switch between proxy and instrumental values for ENSO (purple) and SAM (brown).*

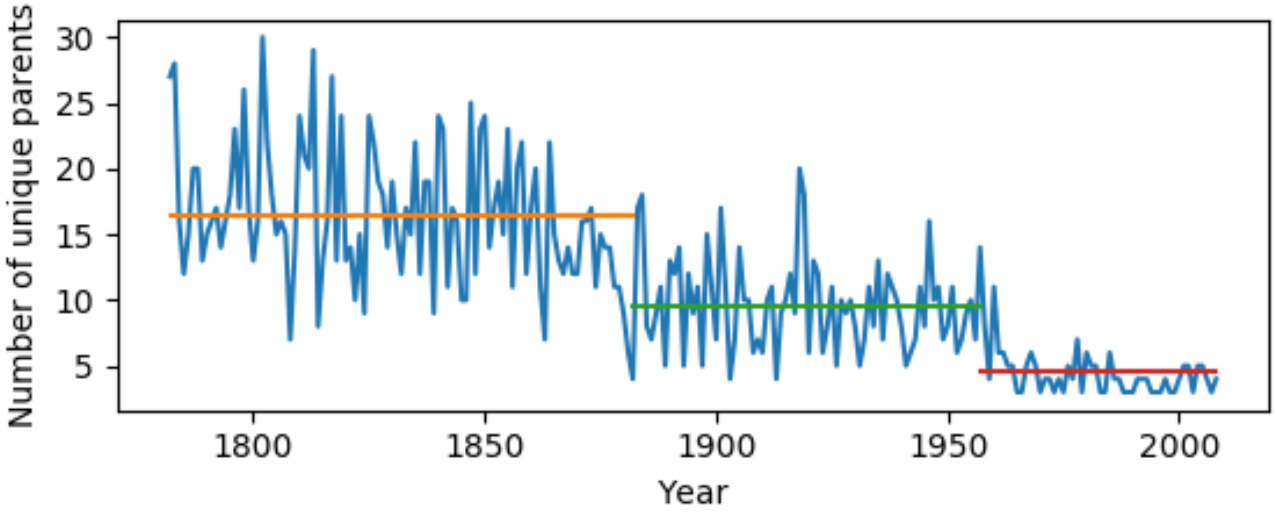

Figure S3 – Number of particles re-spawned. The horrizontal lines show the mean of the period 1781-1881 (16.5 particles), 1882-1956 (9.6 particles) and 1957-2008 (4.5 particles). Indicating that as the uncertainties of the observed metrics decrease the filter has less and less particles which adequately match these modes within the uncertainties,

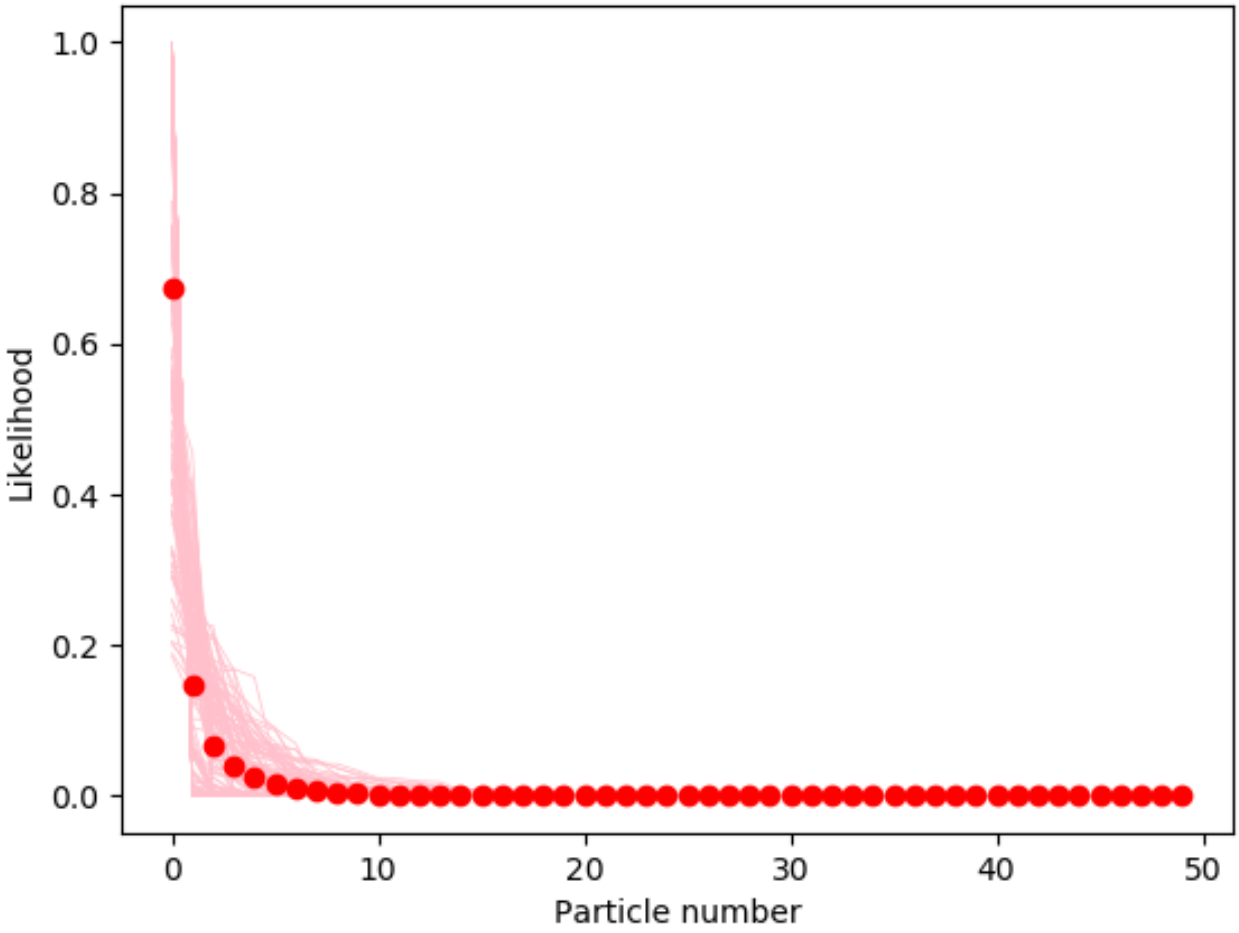

Figure S4 – Likelihood distribution for the 50 particle members for all years between 1882-2008. *Pink lines are the size-ordered likelihood distribition given by eq. 1 and red circles the mean over every year. So values plotted for particle #1 are for the most likely particle in that year, and particle #2 the second most likely, etc. The mean values are used to calculated the weighted mean of the* forcing-only *simulations used in figure 6 (note that for this, the likelihood of all particles less likely than the 10th are set to zero because there are only 10* forcing-only *simulations to average and the remaining 10 particles divided by their sum so that the combined likelihood again sums to one. The first 10 particles encompass over 93% of the total likelihood).*

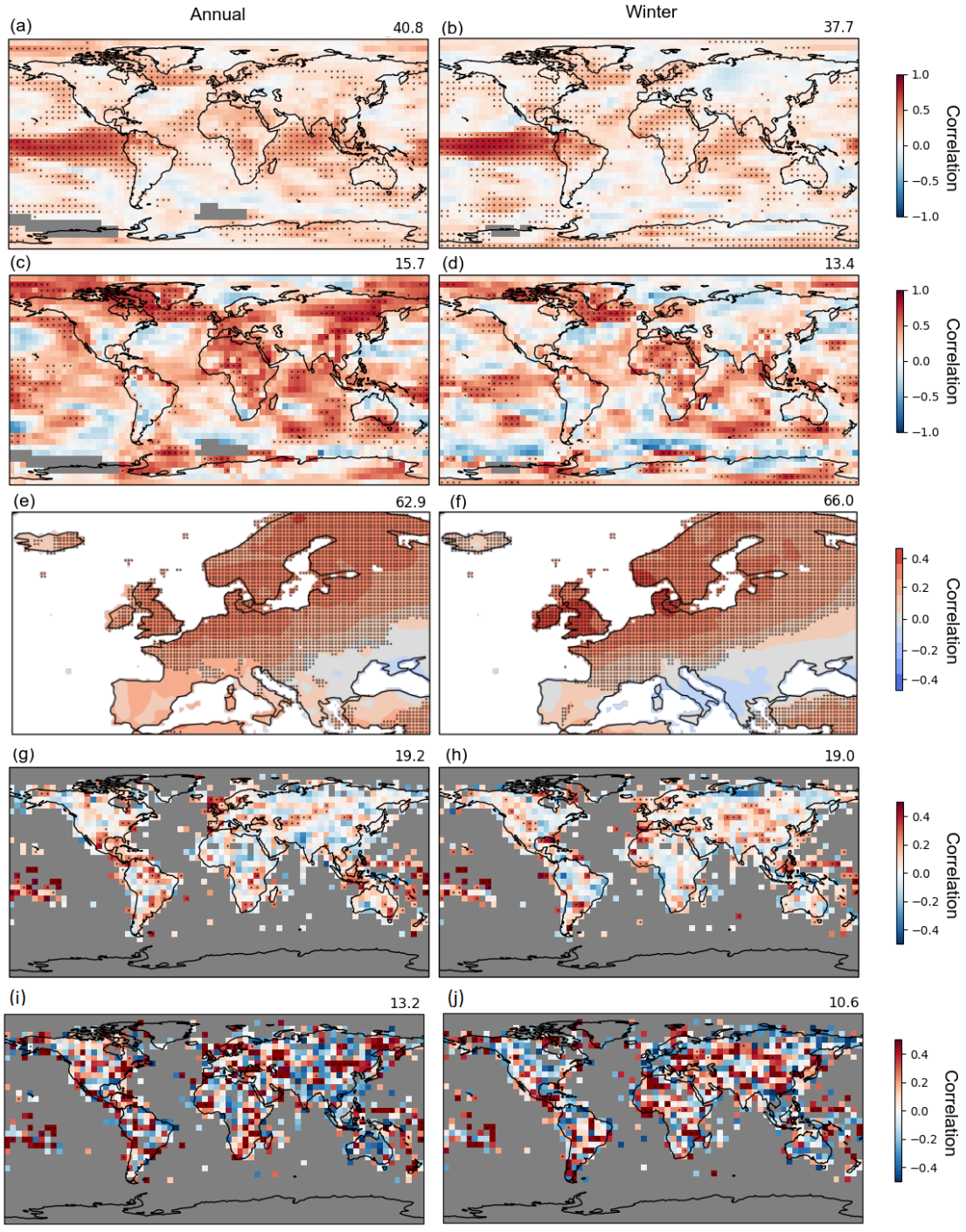

Figure S5 – Annual and winter (djf) correlation between temperature in observations and assimilated model. *As in figure 6 but correlations given as the raw correlations between assimilated model and observations rather than the improvement in correlation (with the correlation of the forced component removed).*

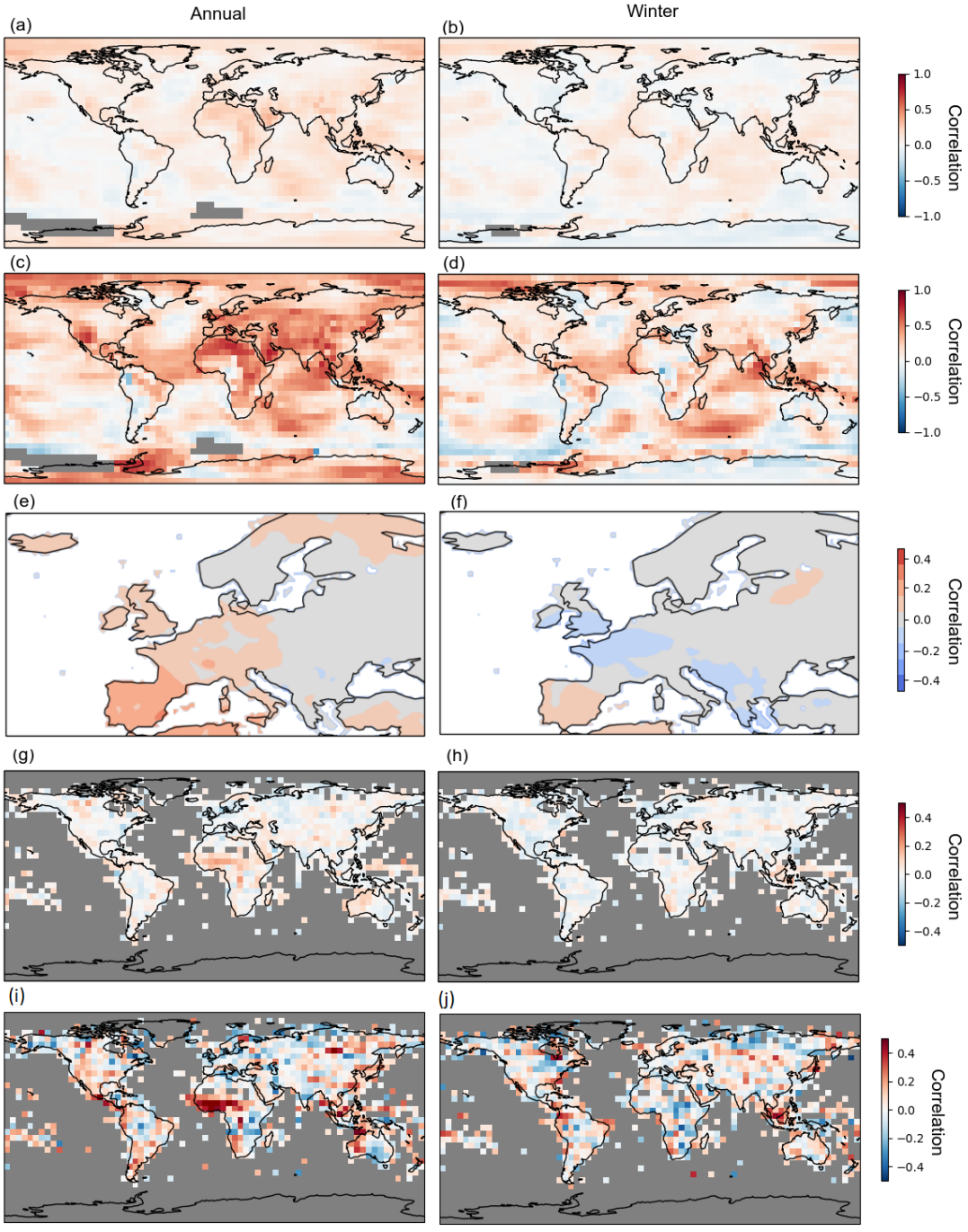

Figure S6 – Annual and winter (djf) mean correlation between temperature in observations and a weighted mean of forcing-only model simulations (with no assimilation). *As in figure 6 but correlations given as the raw correlations between the weighted ensemble mean of the* forcing-only *simulations and observations, i.e. results show the forced component.*

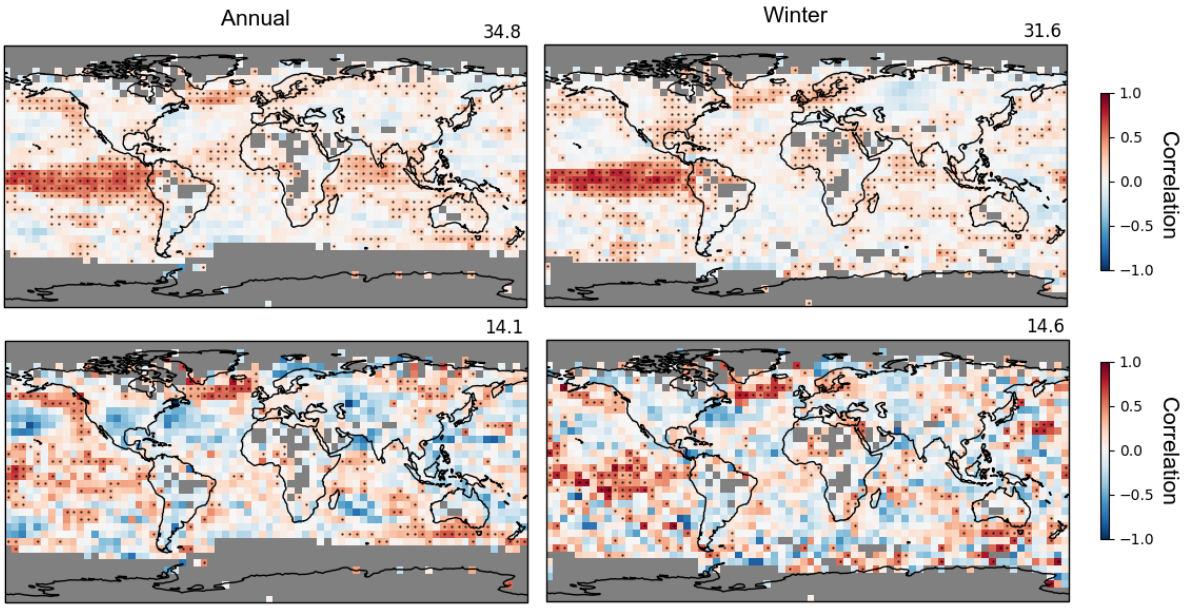

Figure S7 – Improvemnet in annual and winter (djf) correlation between temperature in observations and assimilated model (with the forcing removed). *Same as figure 6a-d except the correlations have been calculated against a version of HadCRUT5 with no infilling.*

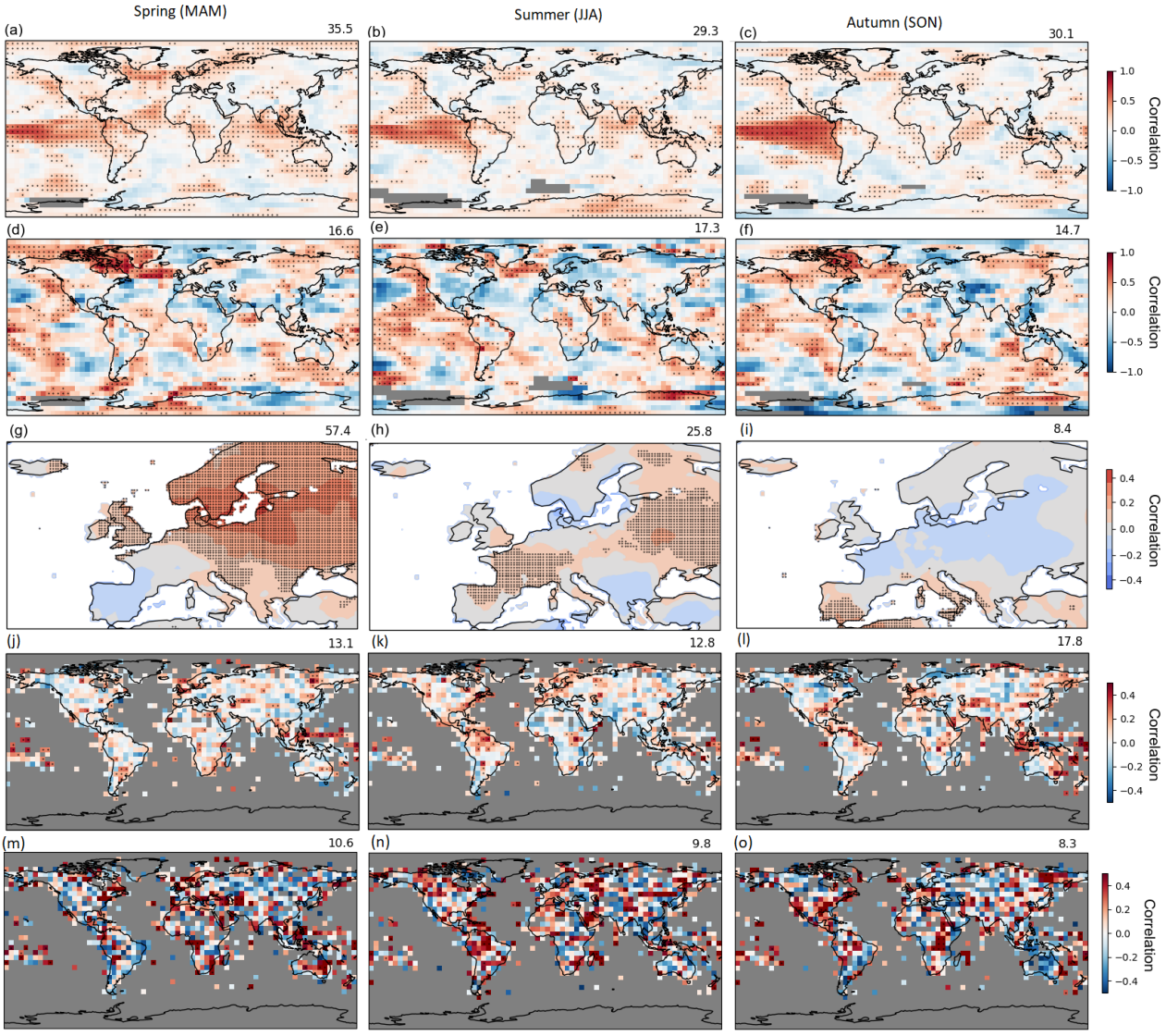

Figure S8 – Improvement in correlation in Boreal spring (mam), summer (jja) and autumn (son). *All panels the same as figure 6 but for different seasonal means.*

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References

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