

Historical time-variation in climate sensitivity related to the nature of the forcing

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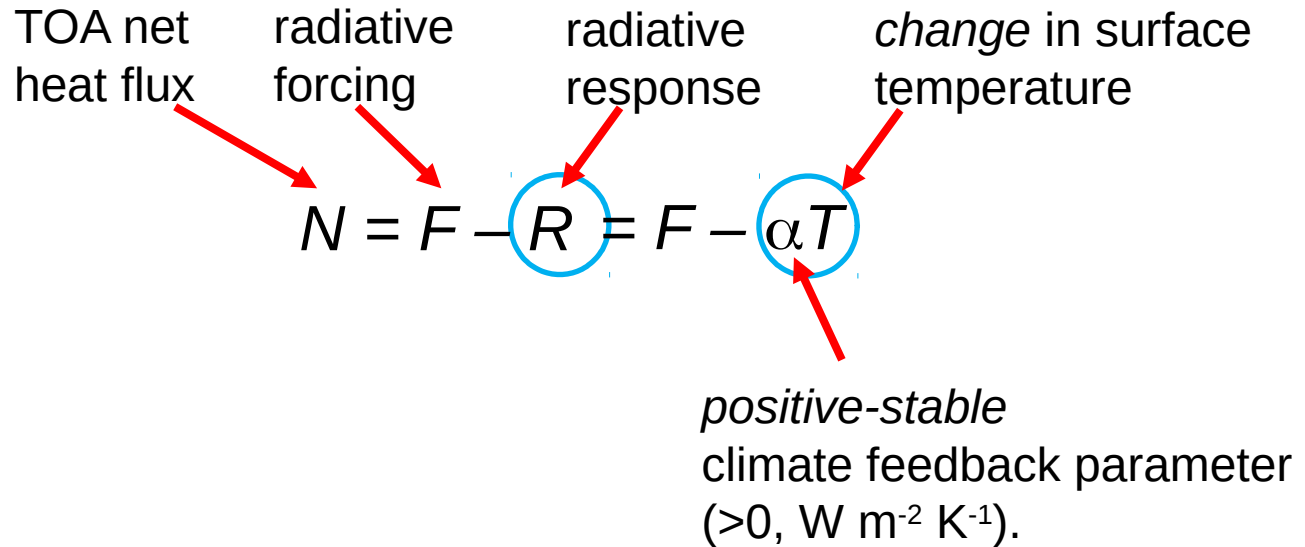
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Global energy balance

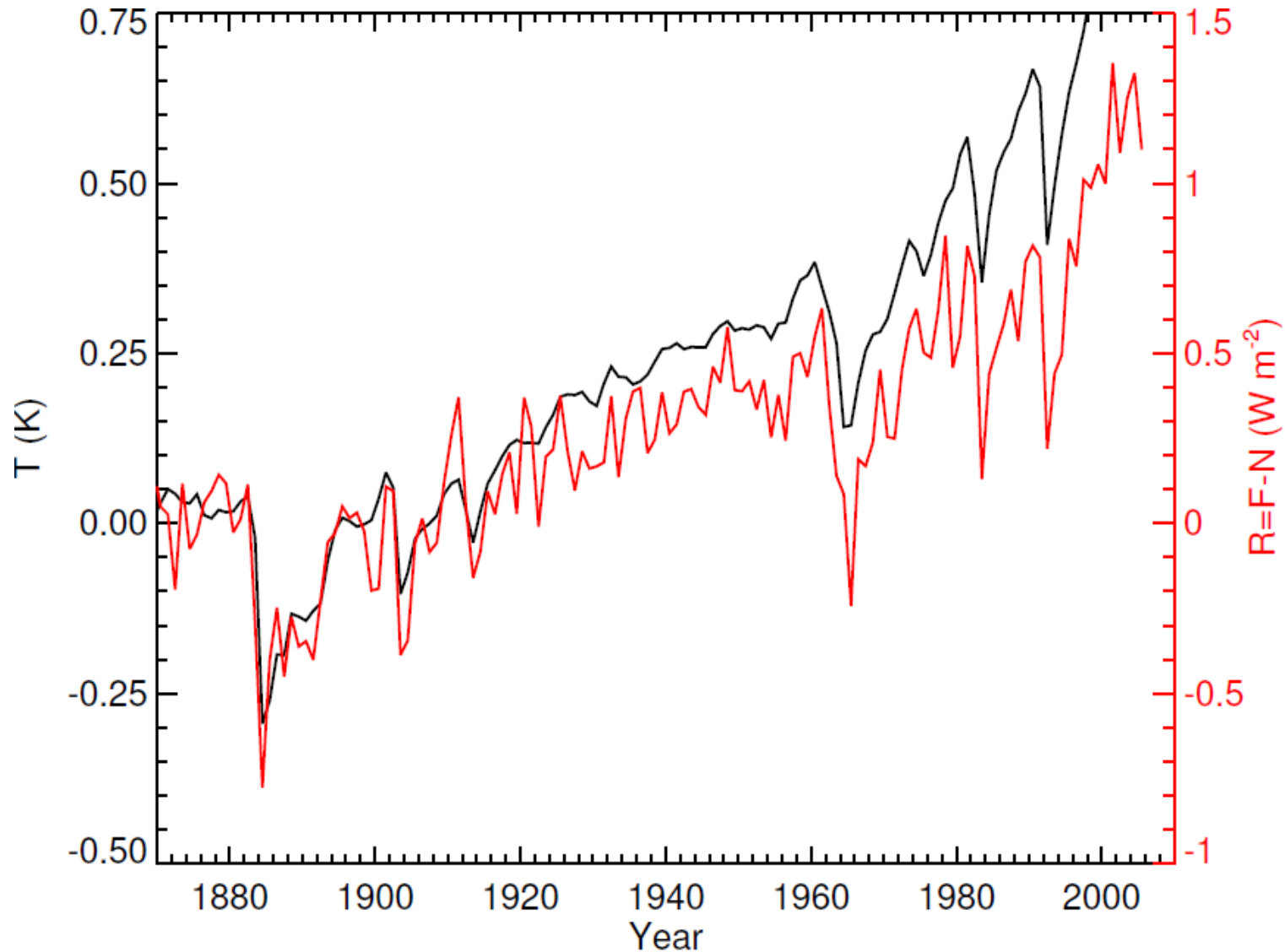


Equilibrium climate sensitivity (ECS) is F_{2x}/α

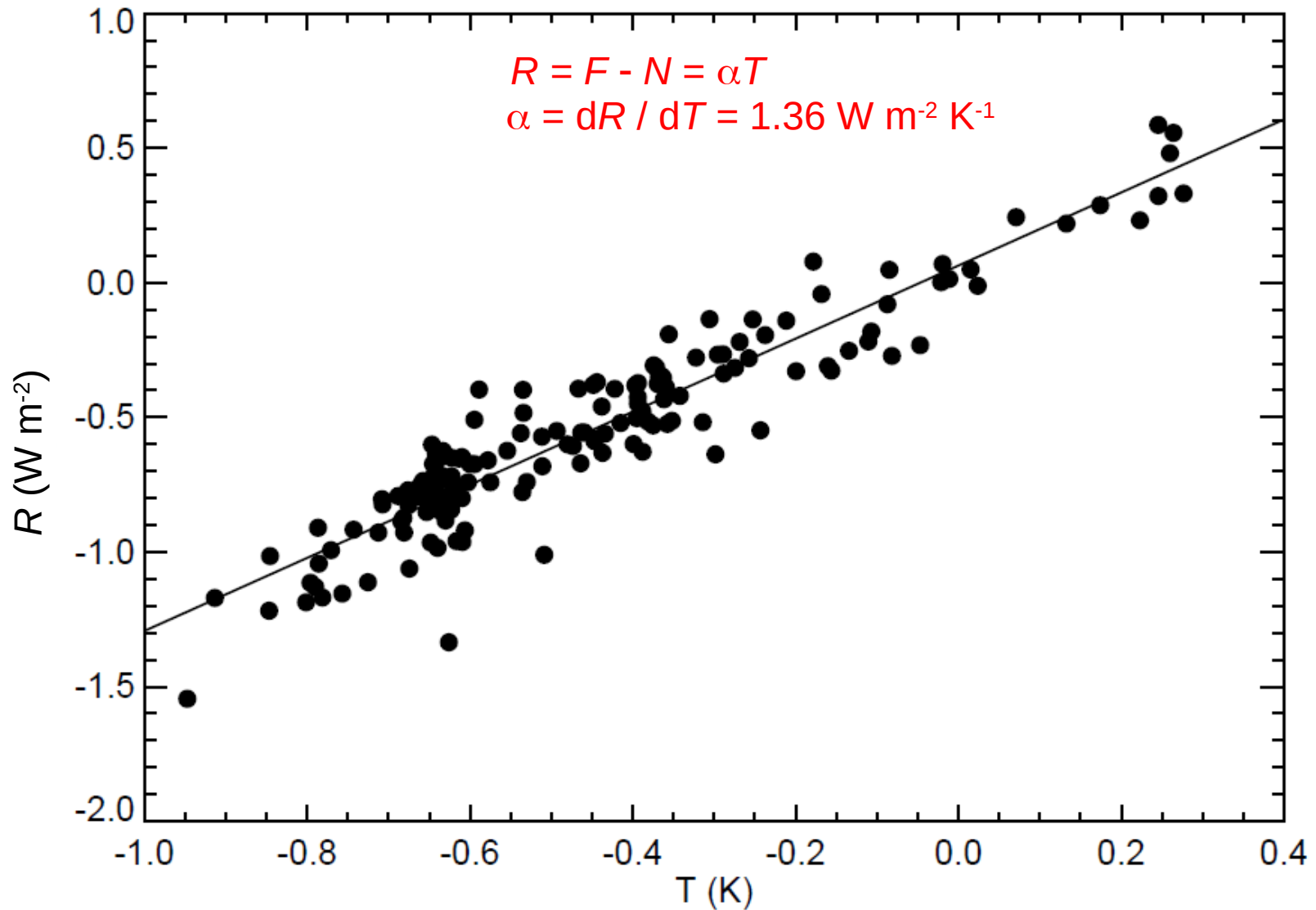
double- CO_2
forcing

We would like to estimate $\alpha = dR/dT = d/dT (F - N)$, from historical F , N and T .

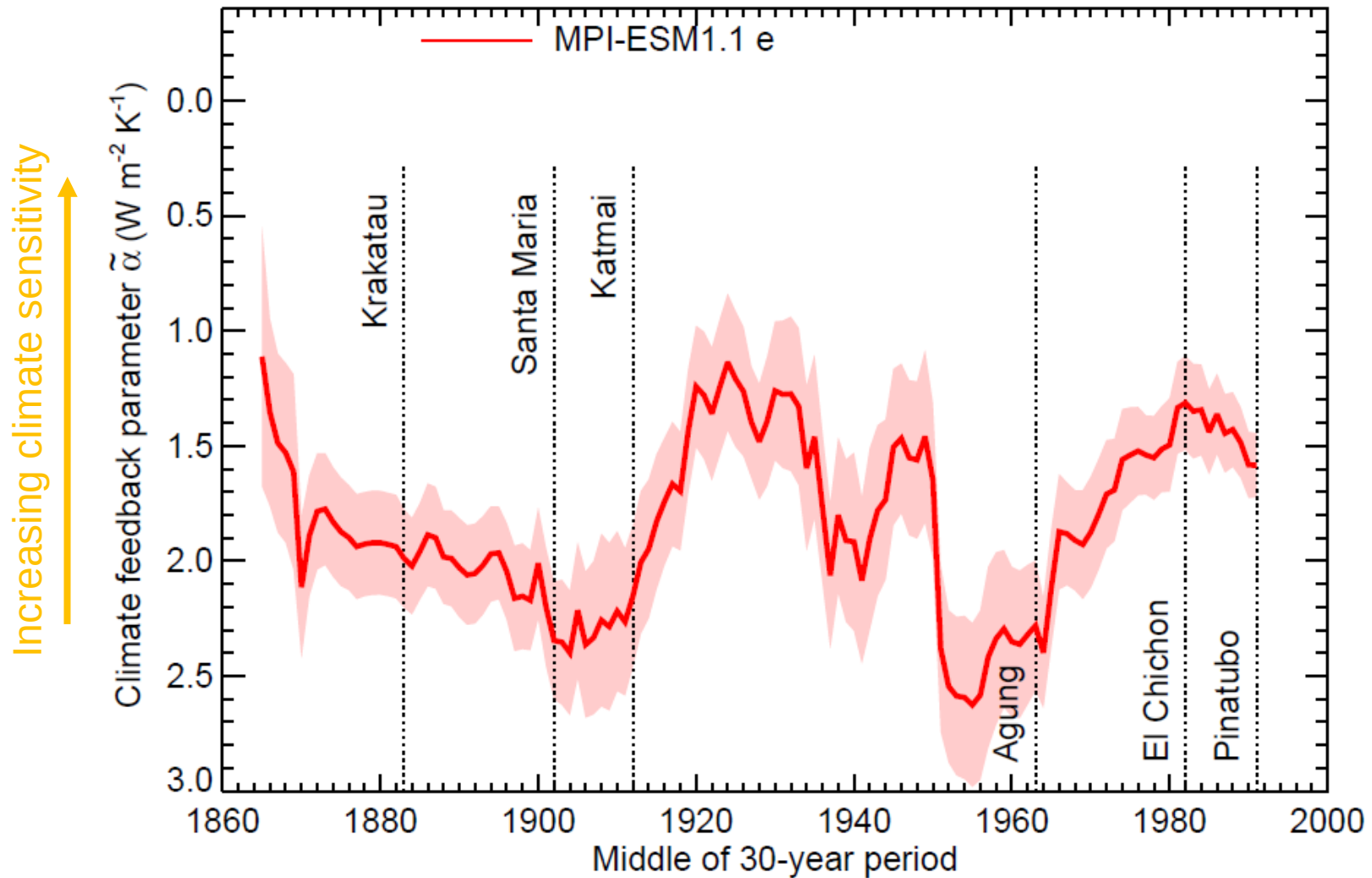
MPI-ESM1.1 historical 100-member-mean



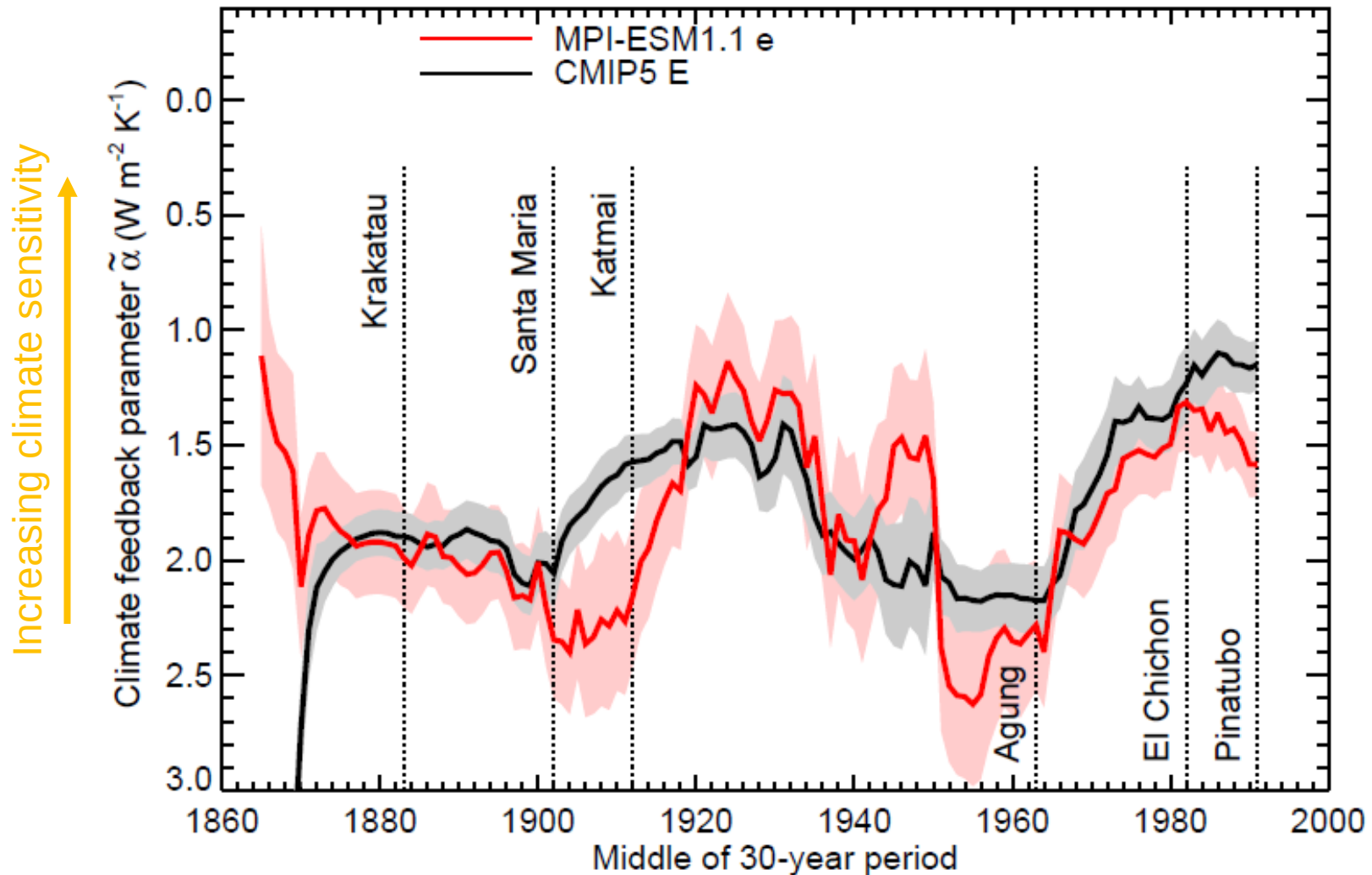
MPI-ESM1.1 historical 100-member ensemble R v T



MPI-ESM1.1 historical $\tilde{\alpha}(t)$

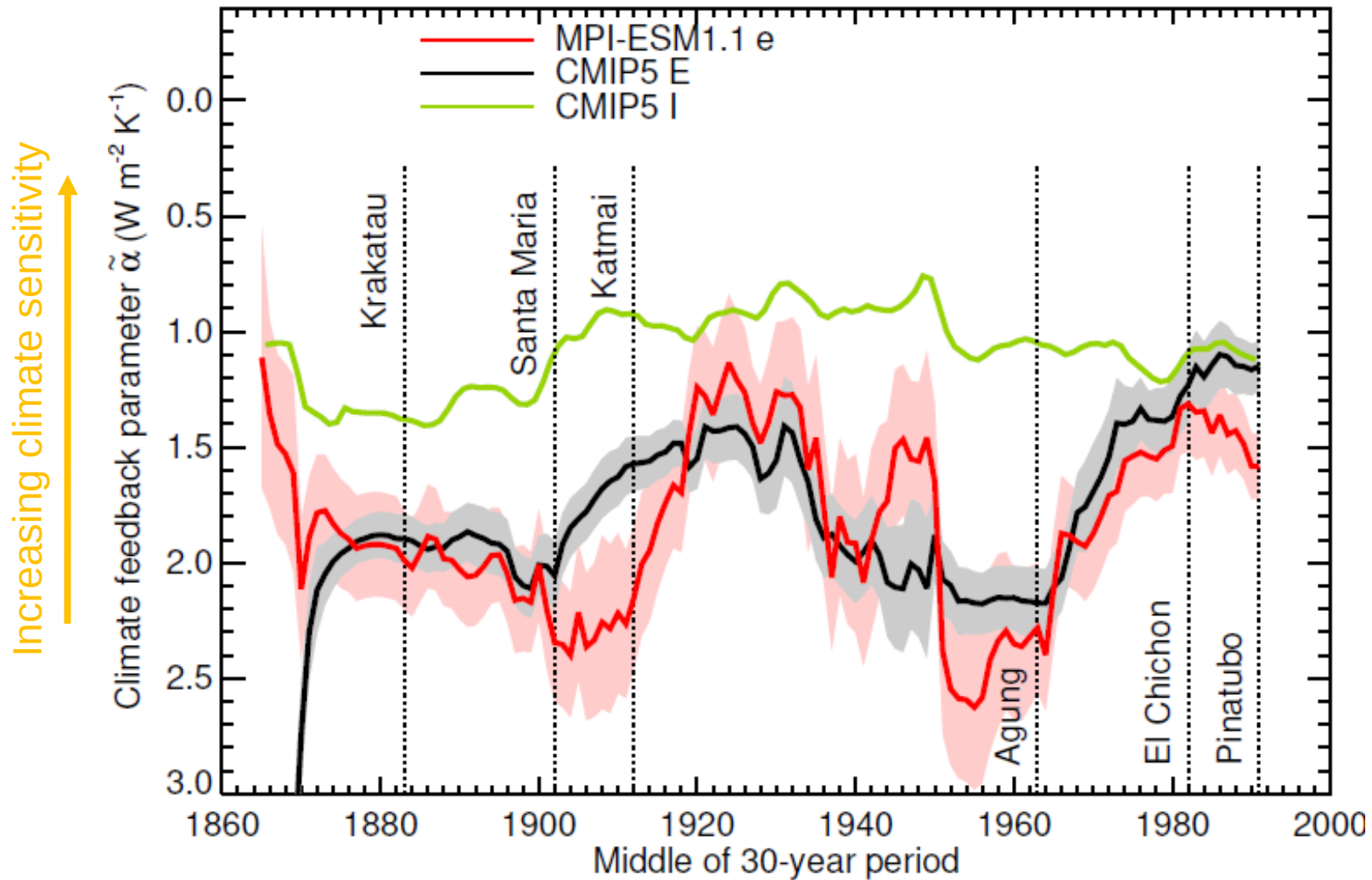


CMIP5 and MPI-ESM1.1 historical $\tilde{\alpha}(t)$



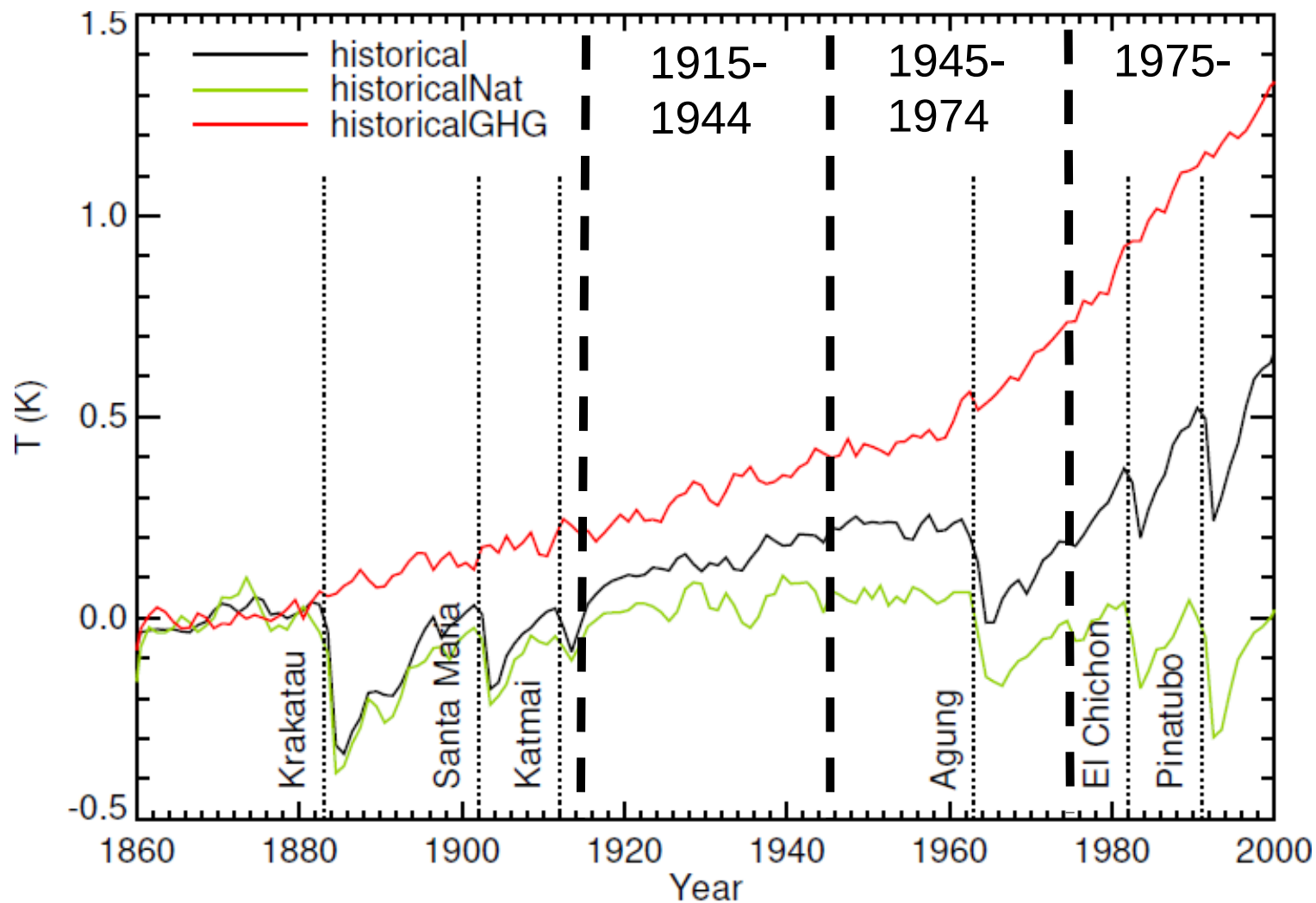
NB AR5 anthropogenic aerosol forcing multiplied by 1.5 for CMIP5

CMIP5 and MPI-ESM1.1 historical $\tilde{\alpha}(t)$

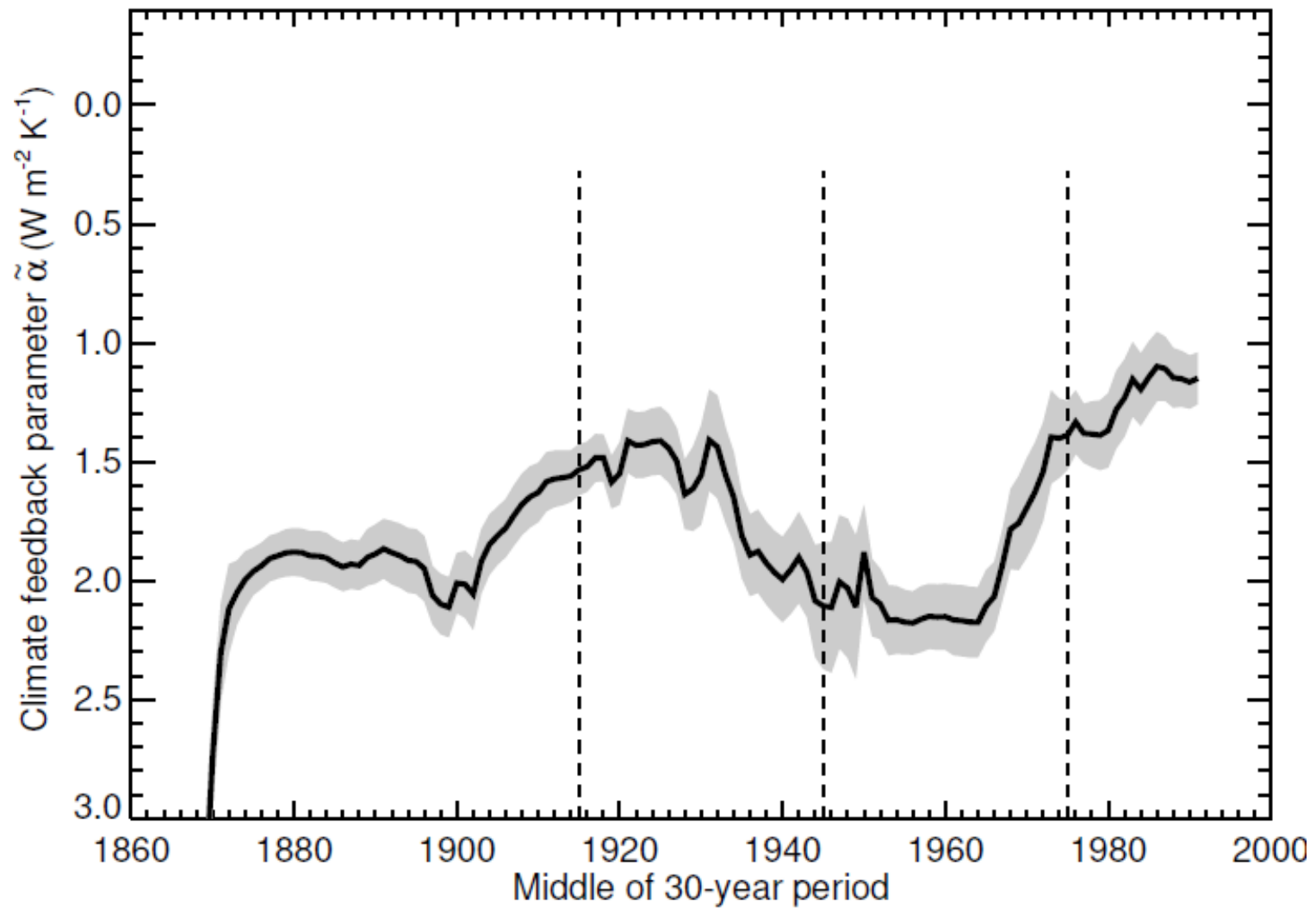


NB AR5 anthropogenic aerosol forcing multiplied by 1.5 for CMIP5

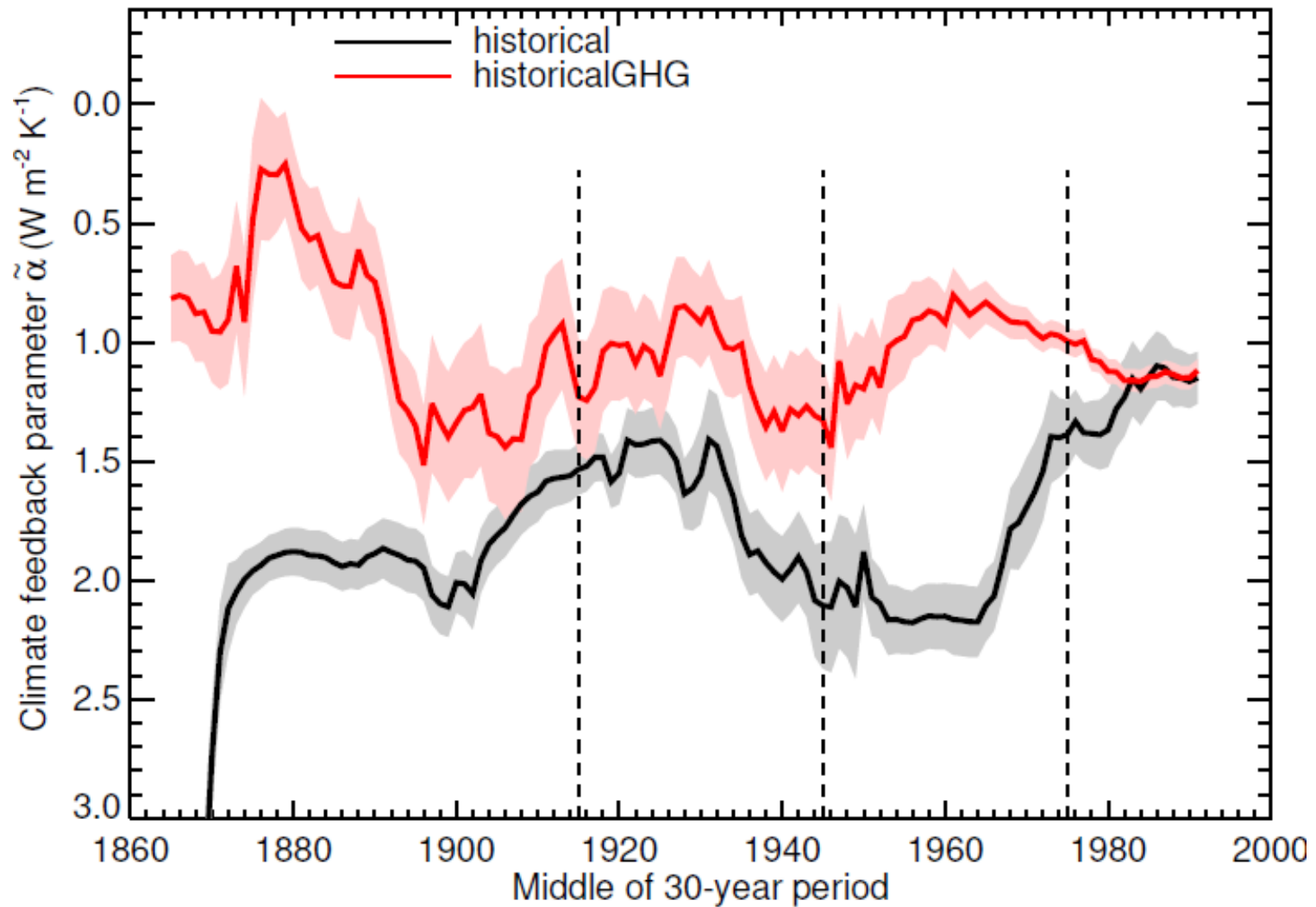
CMIP5 historical[GHG|Nat] T



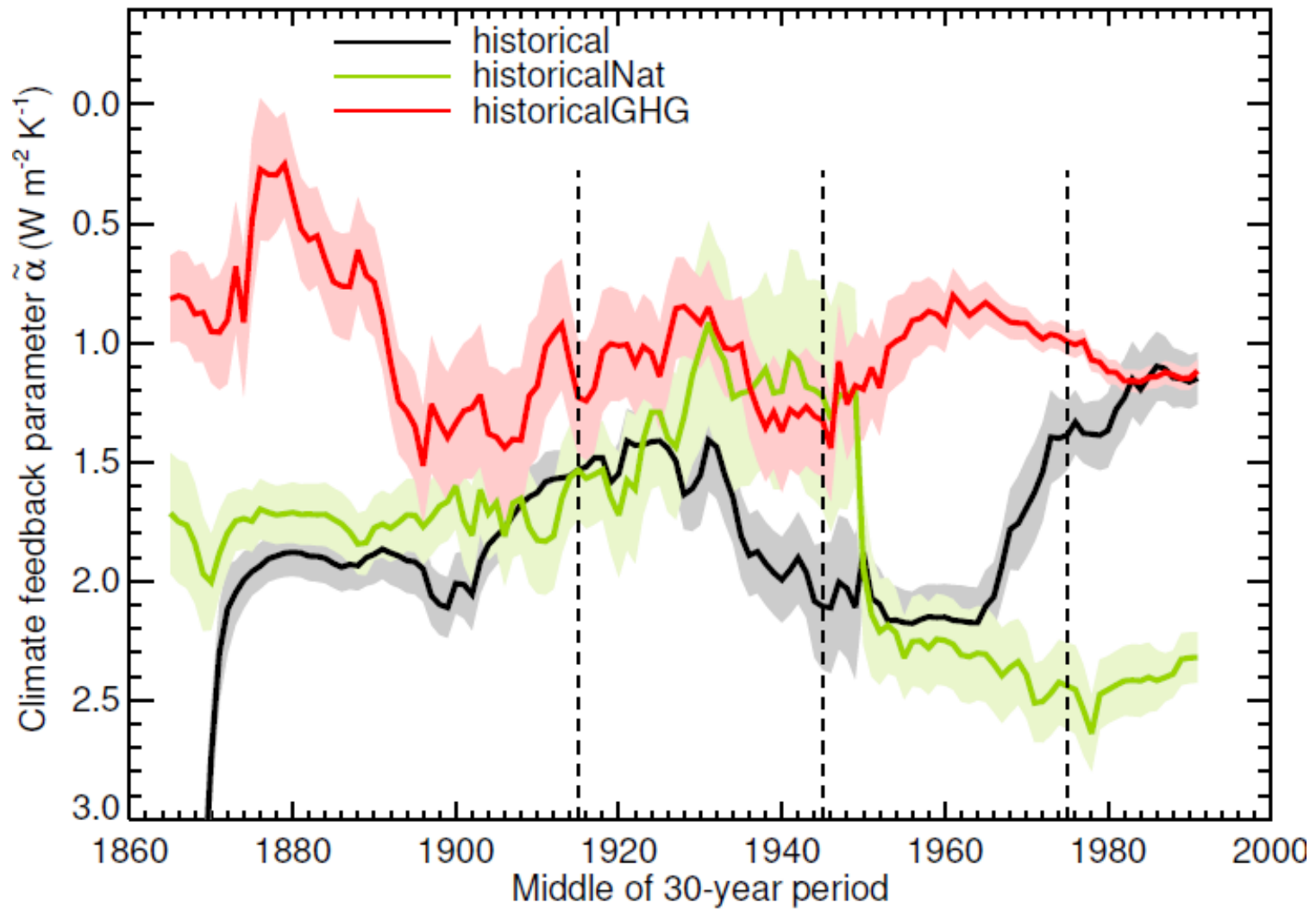
CMIP5 historical $\tilde{\alpha}$



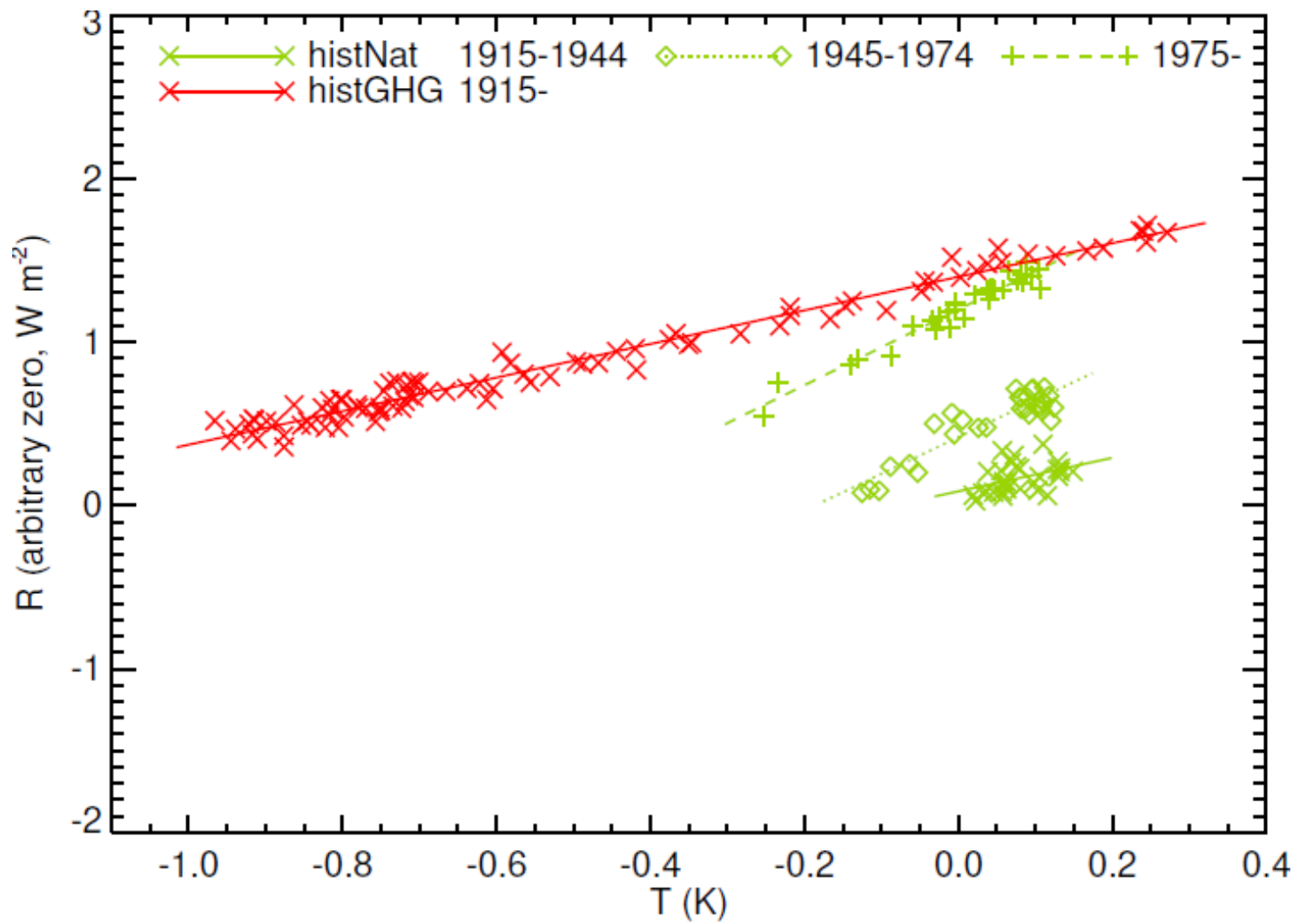
CMIP5 historical[GHG] $\tilde{\alpha}$



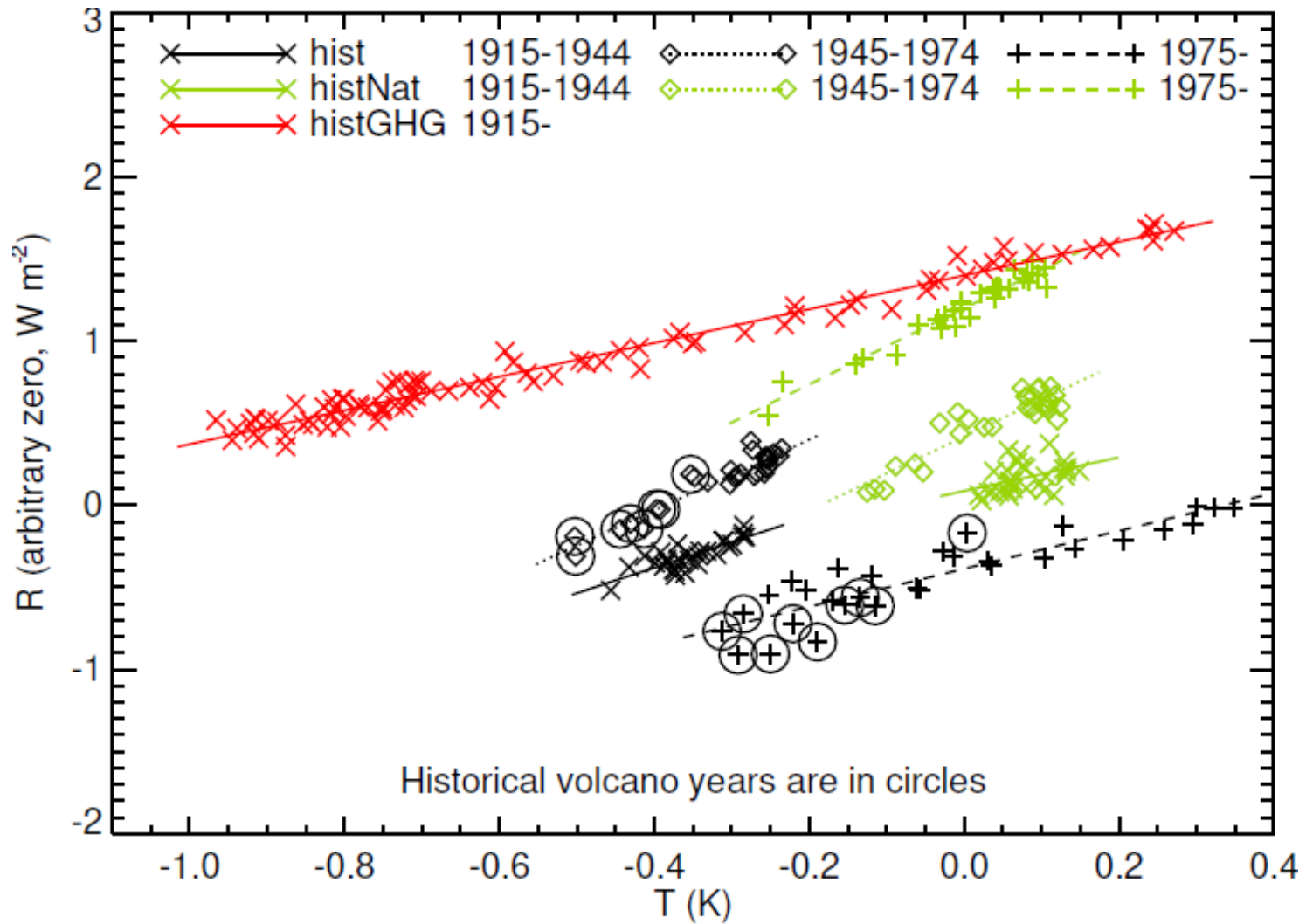
CMIP5 historical[GHG|Nat] $\tilde{\alpha}$



CMIP5 historical{GHG|Nat} R v T



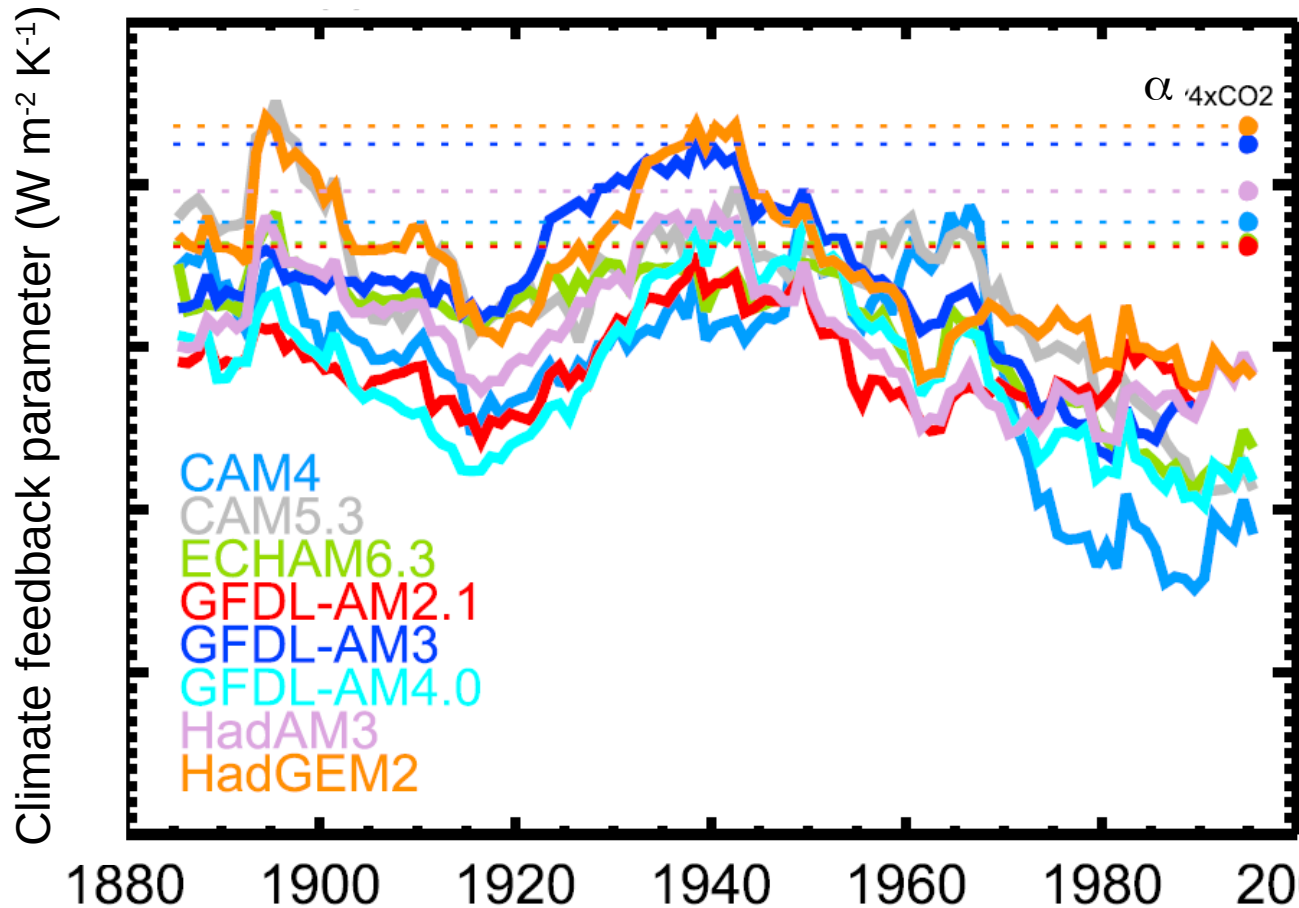
CMIP5 historical[GHG|Nat] R v T



amip-piForcing $\tilde{\alpha}$

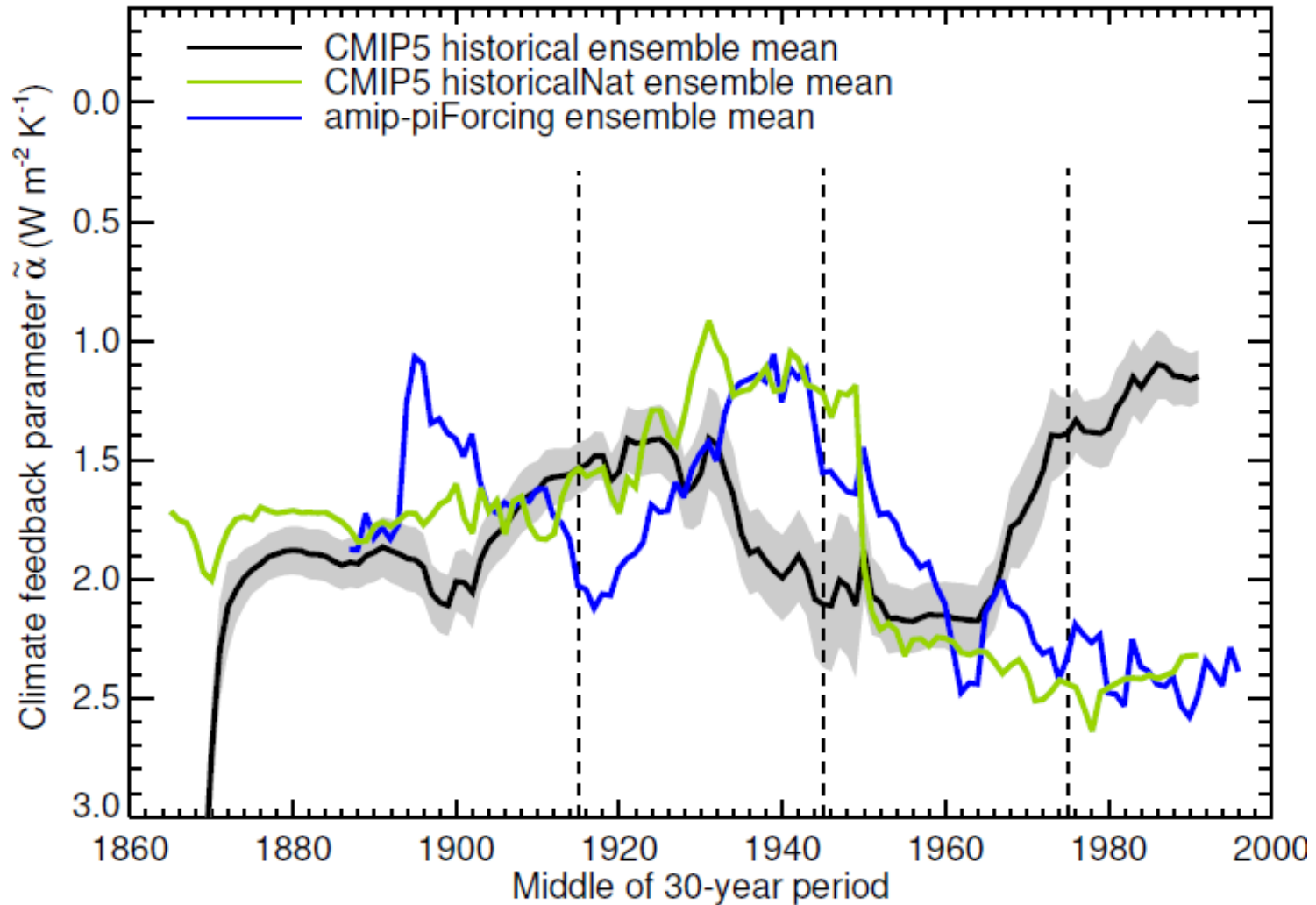
Prescribe T in AGCM and omit forcing agents ($F = 0$)

$$N = F - \alpha T \rightarrow N = -\alpha T$$

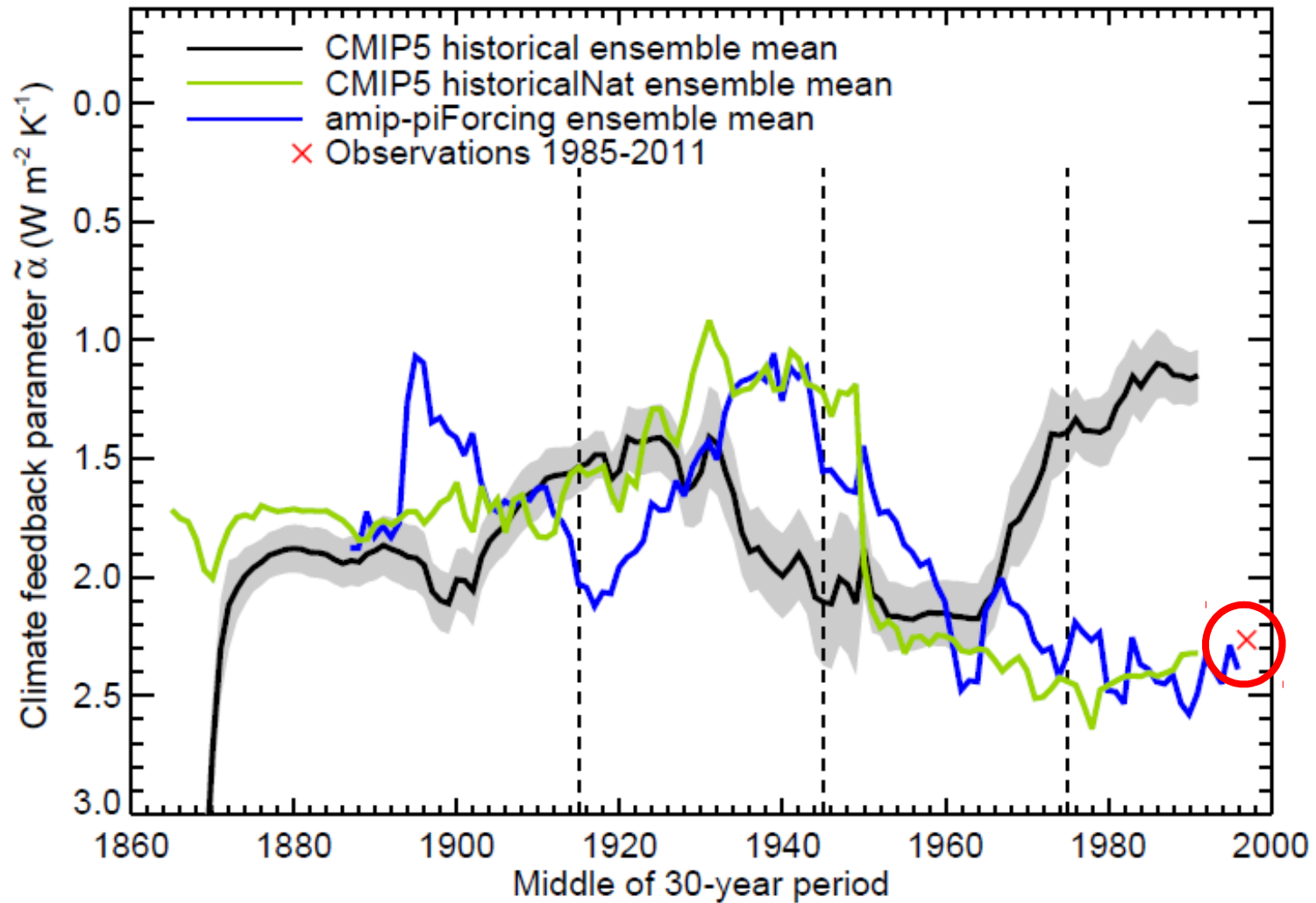


Andrews et al. (2018)

amip-piForcing $\tilde{\alpha}$ and CMIP5 historical[Nat] $\tilde{\alpha}$

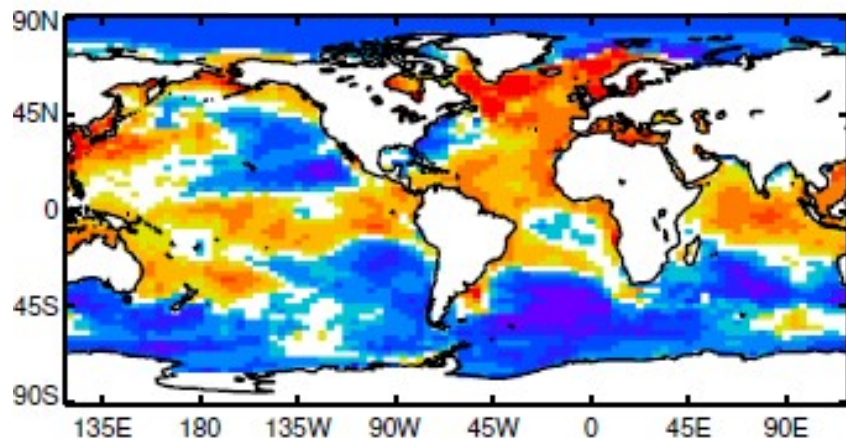


amip-piForcing $\tilde{\alpha}$ and CMIP5 historical[Nat] $\tilde{\alpha}$

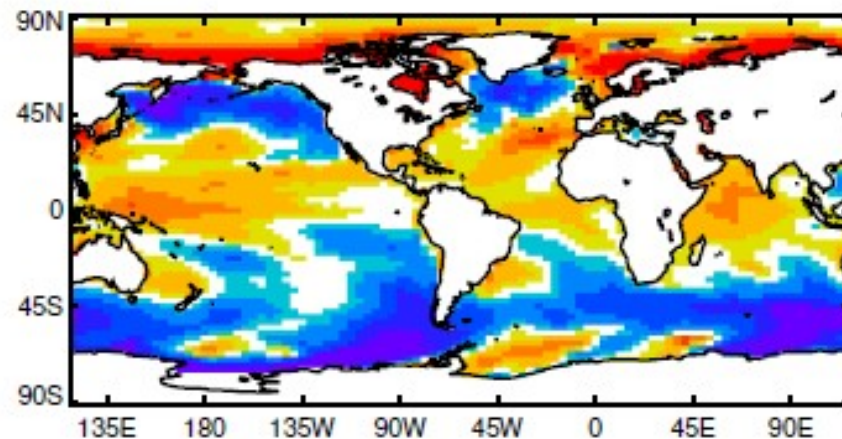


Normalised SST K K⁻¹ patterns 1975-2004

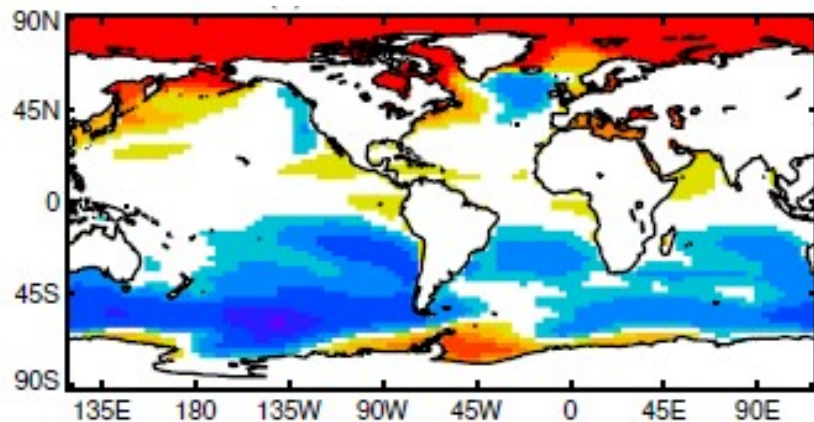
Observational 0.87



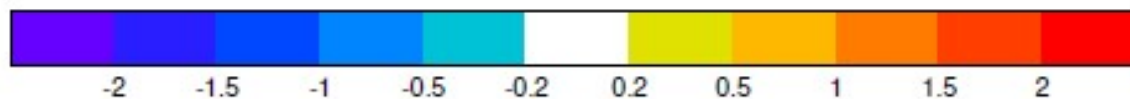
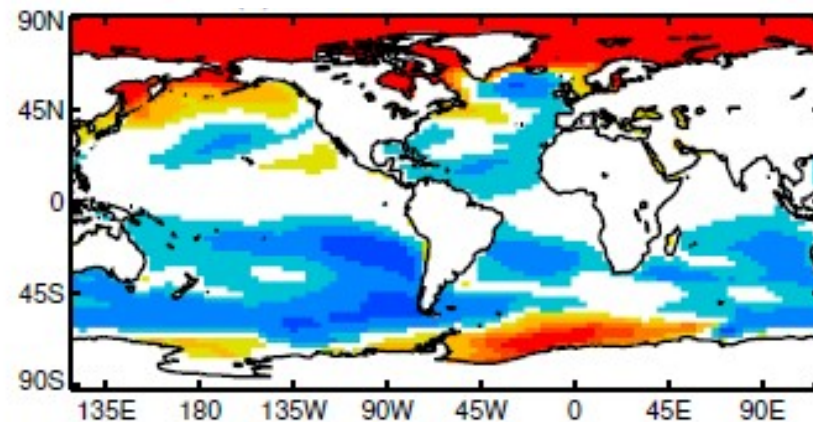
historicalNat 0.21



historicalNat 0.51



historicalNat 0.54



Conclusions

CMIP5 multi-model and MPI-ESM1.1 historical ensemble means show significant decadal variation in climate sensitivity, not discernible in individual integrations.

Climate sensitivity is relatively high around 1930 and since 1975, and relatively low around 1900 and 1960.

The low value is due to volcanic forcing, and the high value is from GHG forcing, which was unopposed around 1930, and overwhelming since 1975.

Time-variations of climate sensitivity are caused by geographical patterns of SST change, which cause changes in R that are not directly related to T .

amip-piForcing shows significant decadal variation, more like historicalNat than historical, especially since 1975, perhaps because the pattern of SST change due to volcanic forcing is stronger in the real world than AOGCMs.

Either unforced variability or forced change in SSTs is not realistic in CMIP5.

We need better understanding of the relationship between the global energy budget and the geographical patterns of climate change.