Supplementary material:

Climate sensitivity estimates – sensitivity to radiative forcing time series and observational data

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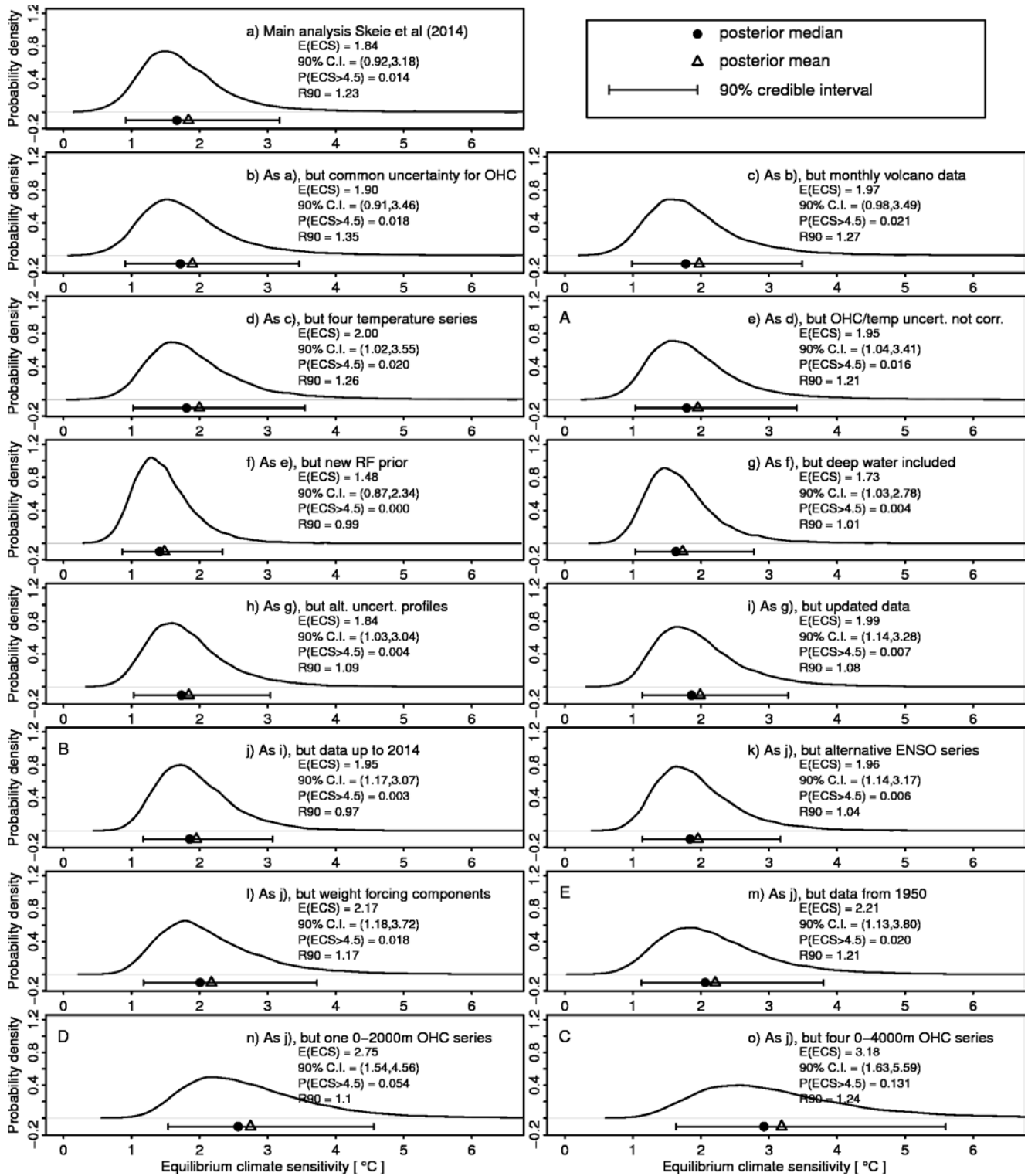
Figure S1. Posterior distributions for the ECS for all the analyses in this work. In (**a**) the main results from Skeie et al. (2014), (**b**) assumed a common observational uncertainty profile for the OHC data, (**c**) replaced yearly volcanic forcing with monthly forcing data, (**d**) included an additional data series for hemispheric temperature, (**e**) assume zero correlation for the temperature and OHC observational errors which is the starting point in the main text (case A), (**f**) replaced the original forcing priors with forcing priors from IPCC AR5 (**g**) included ORAS4 data above and below 700 meter (**h**) use an alternative uncertainty profile for the deep ocean data, (**i**) use updated observational data , (**j**) use observational data up to

and including 2014 (case B), **(k)** using an alternative ENSO index, **(l)** use different weights for the forcing components (see Text S3), **(m)** exclude observational data prior to 1950 (case E), **(n)** use only Levitus2000 OHC data (case D) and **(o)** use four total OHC observational time series but without separating above and below 700 meter (case C). The estimated mean of ECS, the 90% C.I. and the probability of ECS being larger than 4.5°C are given in the text box of each panel as well as the relative uncertainty measure R90 defined as the width of the 90% C.I. divided by the posterior mean. The 90% C.I. (the error bar) and estimated posterior mean (triangle) and median (black dot) are also indicated in each panel. The upper-case letter in the upper left corner indicates the main cases.
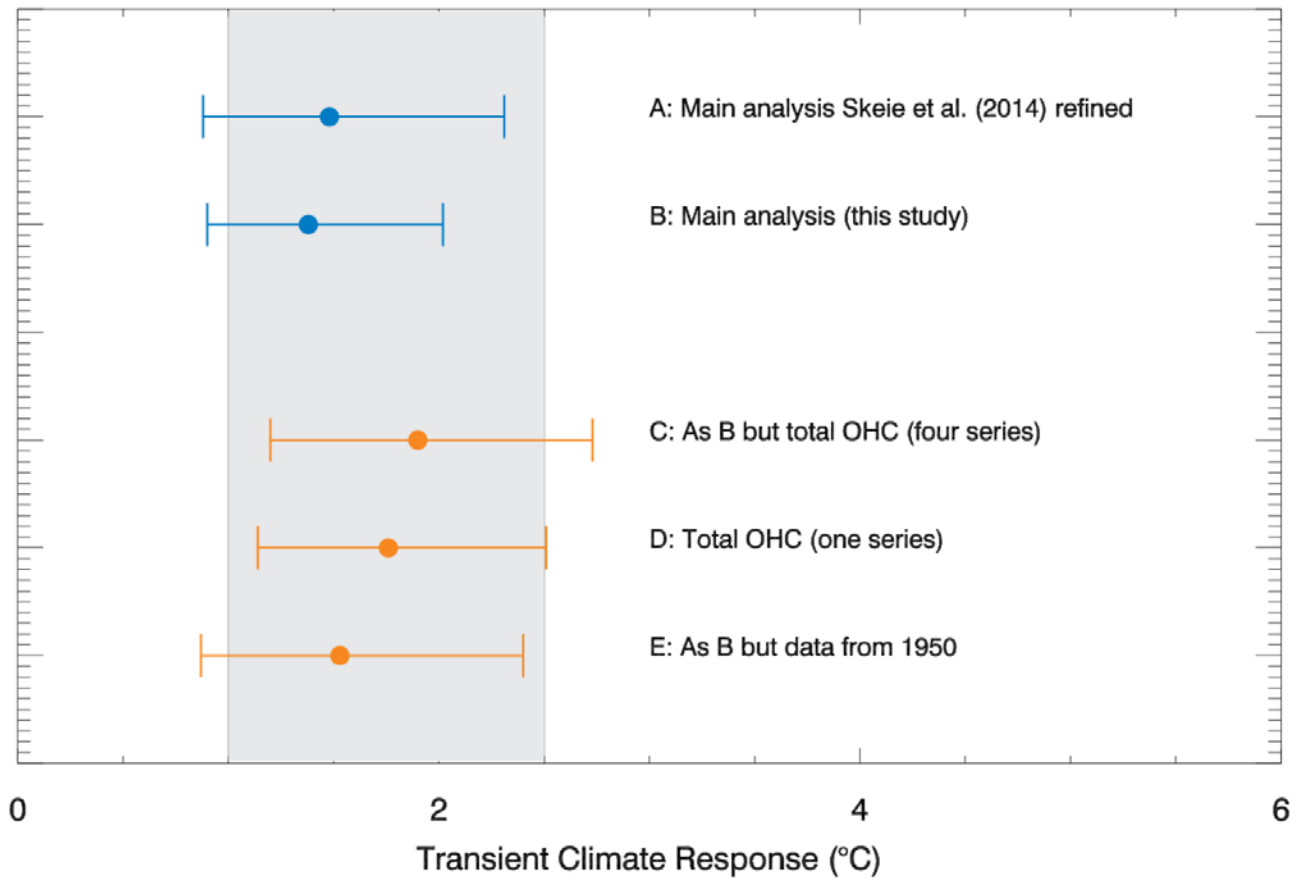
Figure S2. Posterior 90% C.I for TCR for the different analyses. The estimated posterior mean is indicated by a dot. The IPCC AR5 likely range (>66% probability) shown as gray shadings.
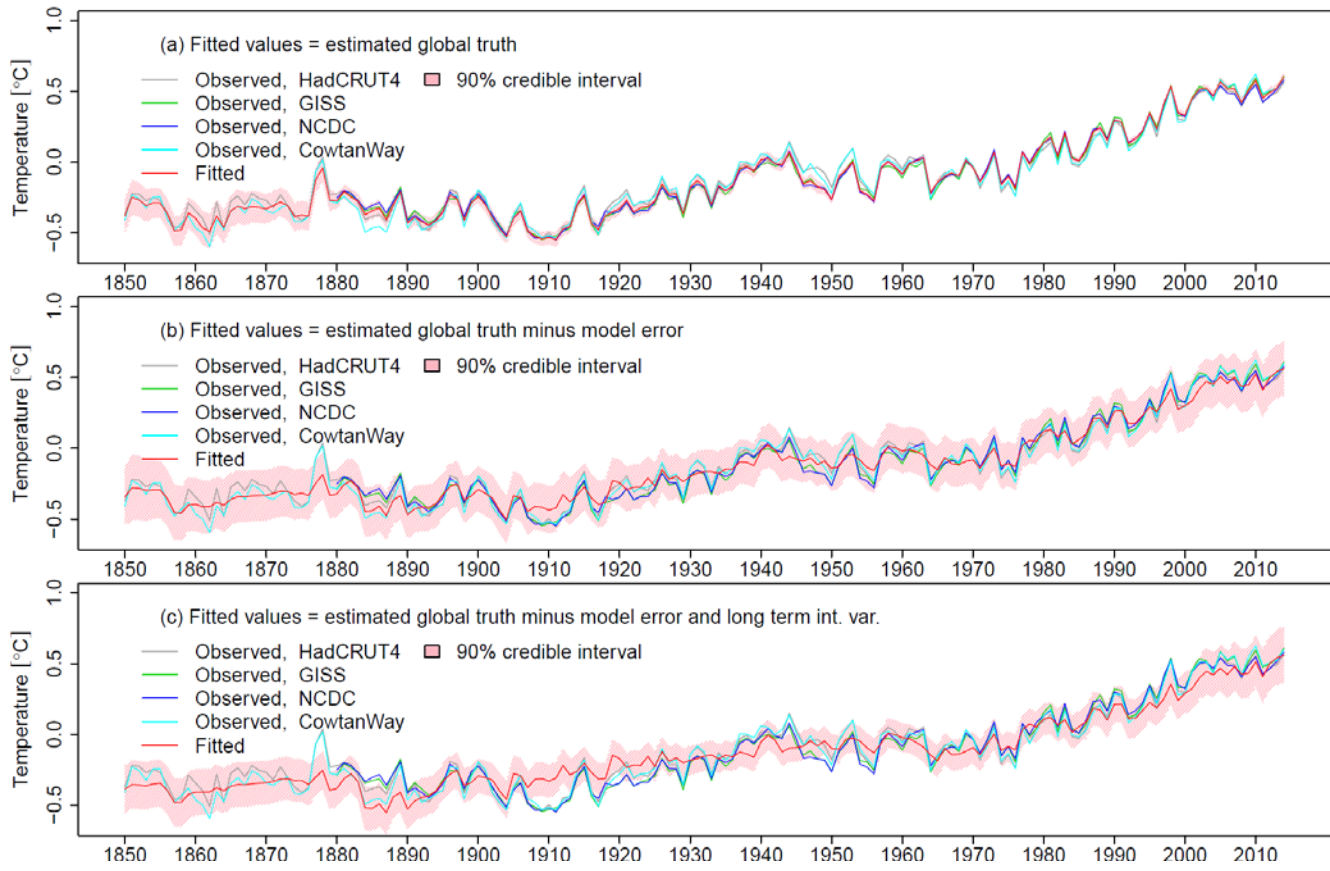
Figure S3 Observed and fitted (posterior mean) values for GMST. The shaded areas show the 90% C.I. for fitted values. In a) the fitted values are the sum of the output from the deterministic SCM including model error and short- and long-term internal variability. In b) the fitted values are the sum of the output from the deterministic SCM and short- and long-term internal natural variability excluding the term for model error. In c) the fitted values are as presented in Fig. 2 i.e. the sum of the output from the deterministic SCM and the short-term internal variability excluding the terms for long-term internal variability and model error.
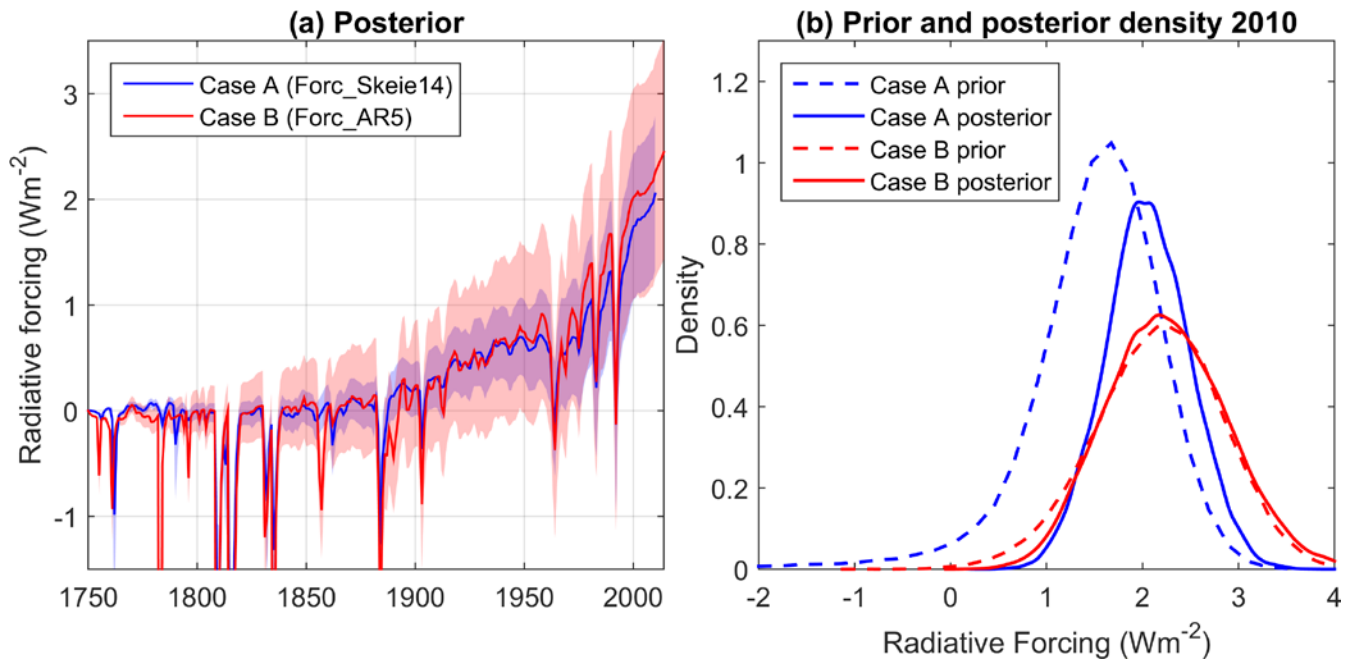
Figure S4. Posterior distribution of time series **(a)** and prior (dotted) and posterior (solid) probability density function (PDF) in 2010 **(b)** for total forcing. The shaded areas in **(a)** represent the 90% C.I.
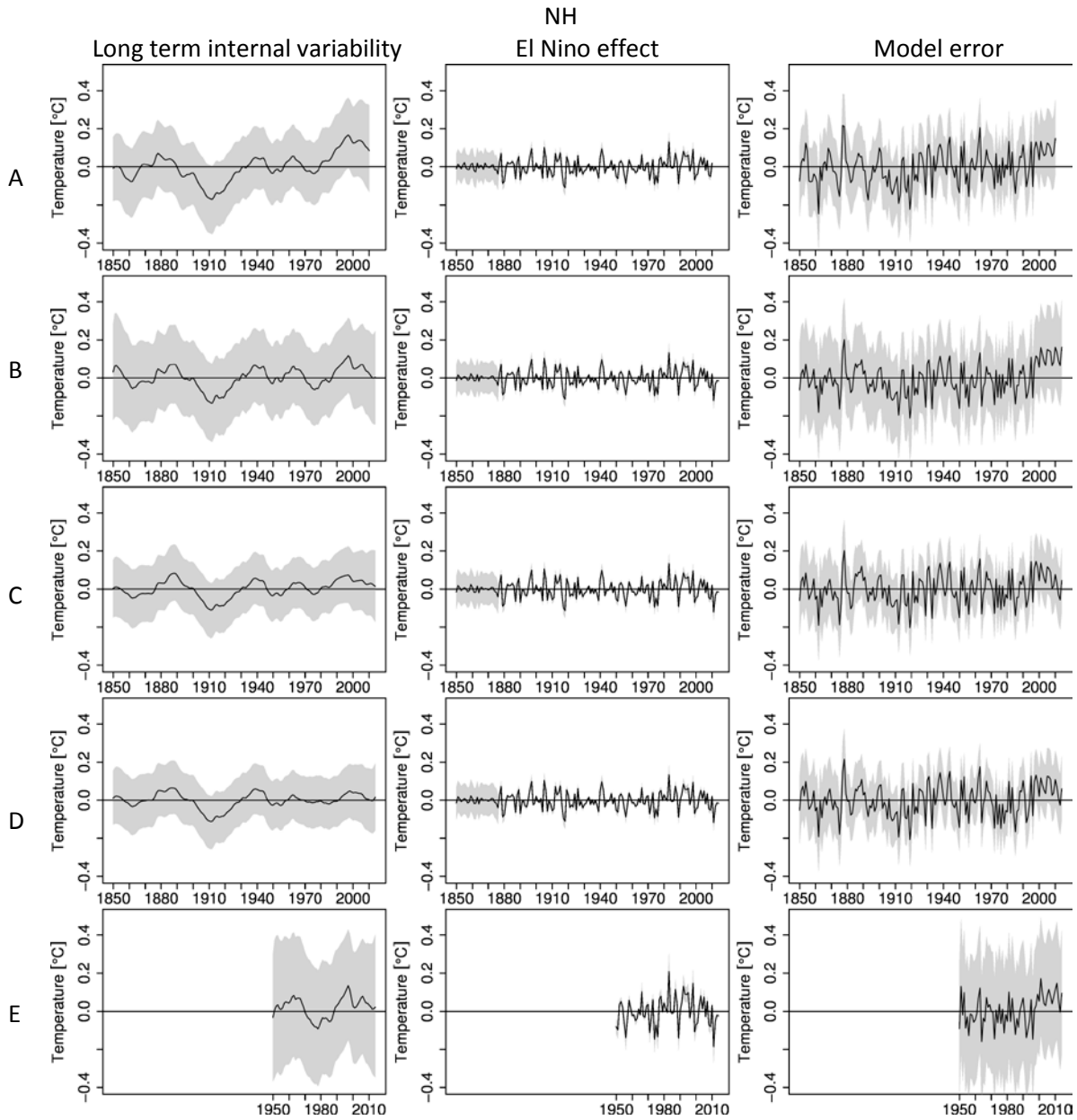
Figure S5a For all main cases (A-E) posterior estimates of the long-term internal variability term (left column), the ENSO term (middle column) and the model errors (right column) for the northern hemispheric temperature.

Figure S5b Same as Fig. S4a but for southern hemispheric temperature.
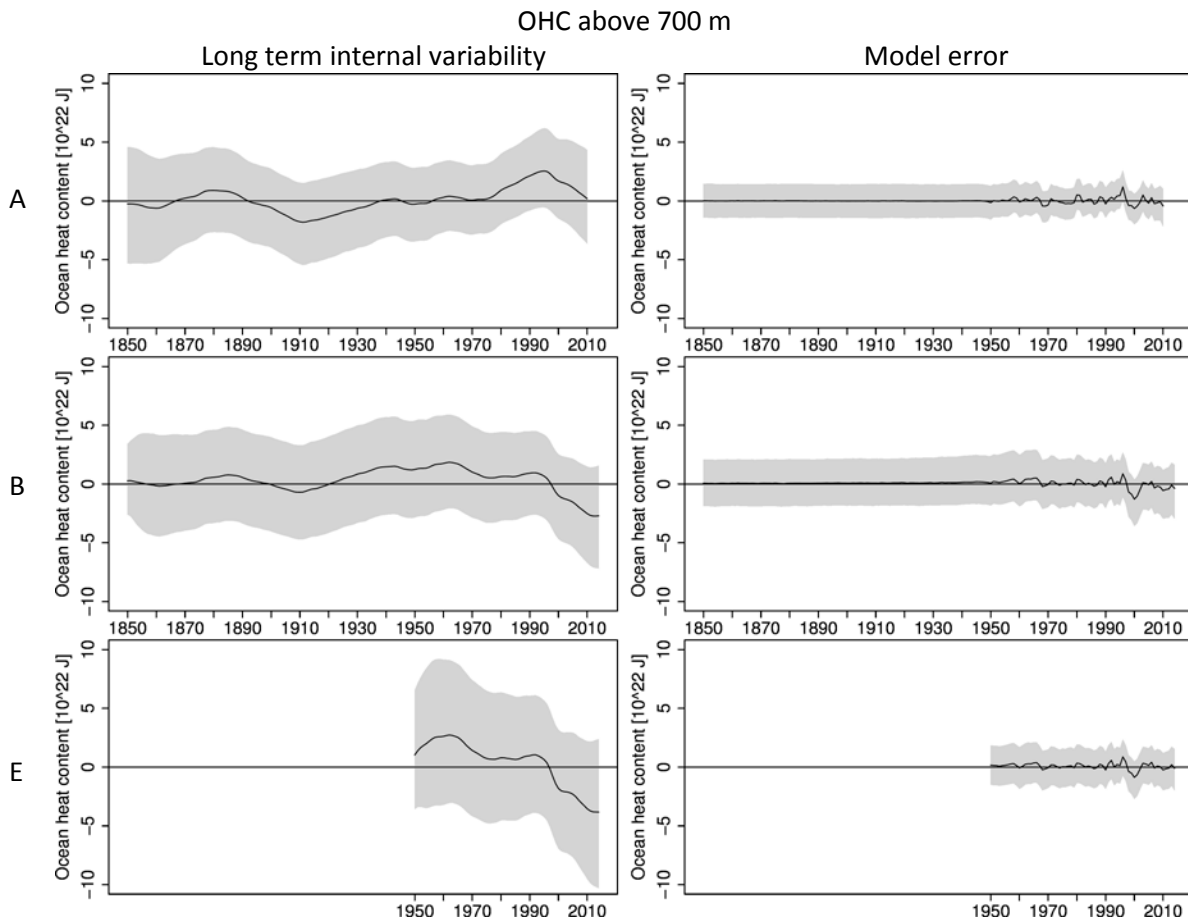
Figure S5c Same as Fig. S4a but for the long-term internal variability term (left column) and the model errors (right column) for the OHC above 700 meter for case A, B, and E.
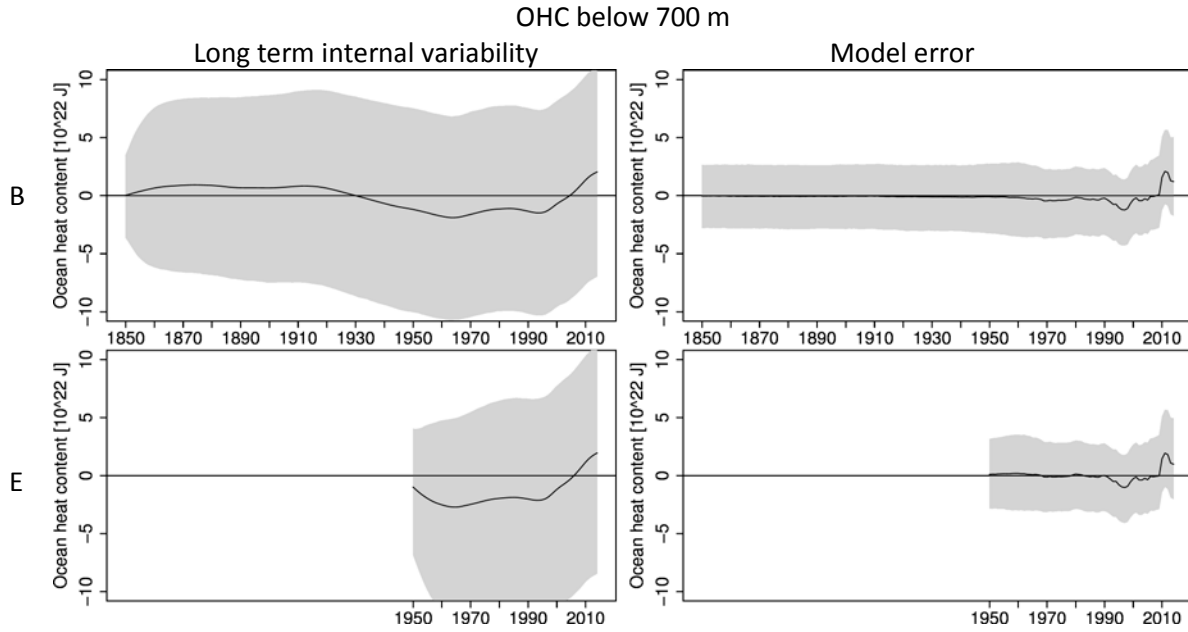
Figure S5d Same as Fig. S4c but for OHC below 700 meter for case B and E.
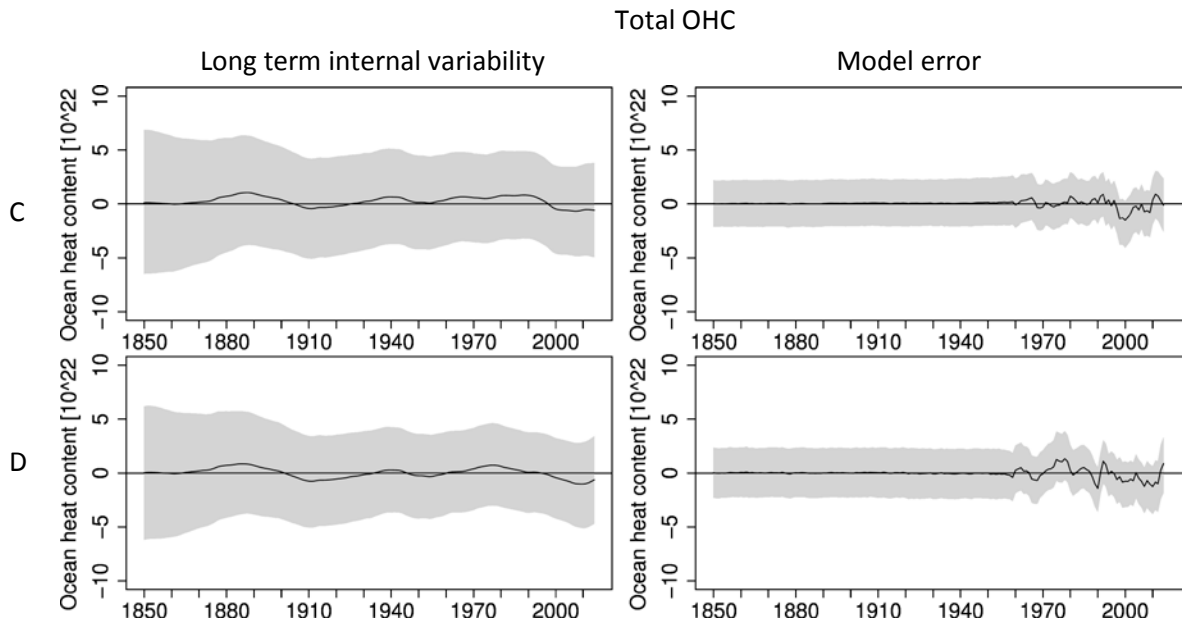
Figure S5e Same as Fig. S4c but for total OHC for case C and D.
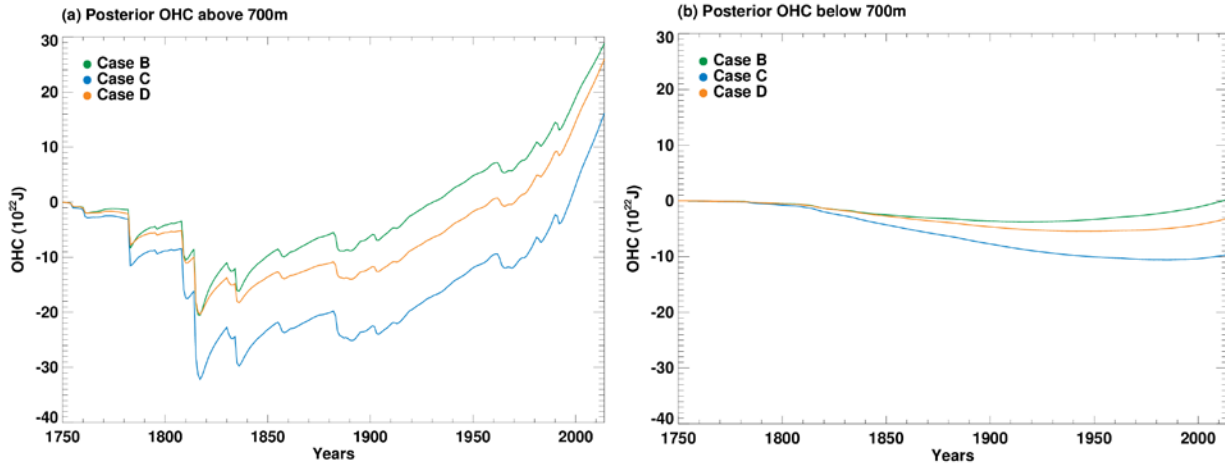
Figure S6. Posterior mean (solid lines) of the output from the deterministic EBC/UDM for OHC above 700 meter (a) and below 700 meter (b) for case B, C and D.
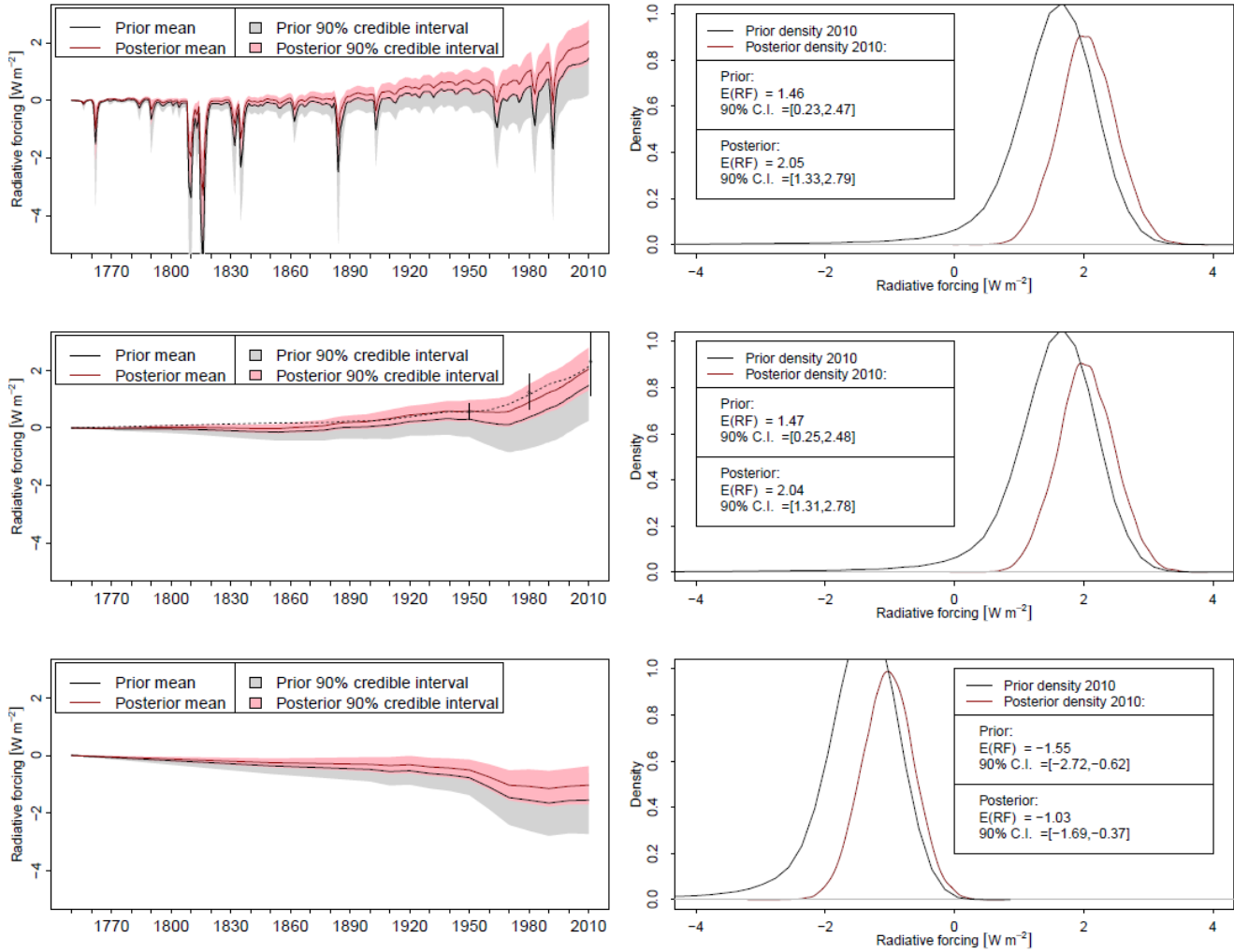
Figure S7a. For Case A the prior and posterior distribution of the RF time series and PDF of RF in 2010 for total RF (upper panel), anthropogenic RF (middle panel) and total aerosol effect (lower panel). Red color for the posterior distributions and black lines and grey shadings for the prior distribution.
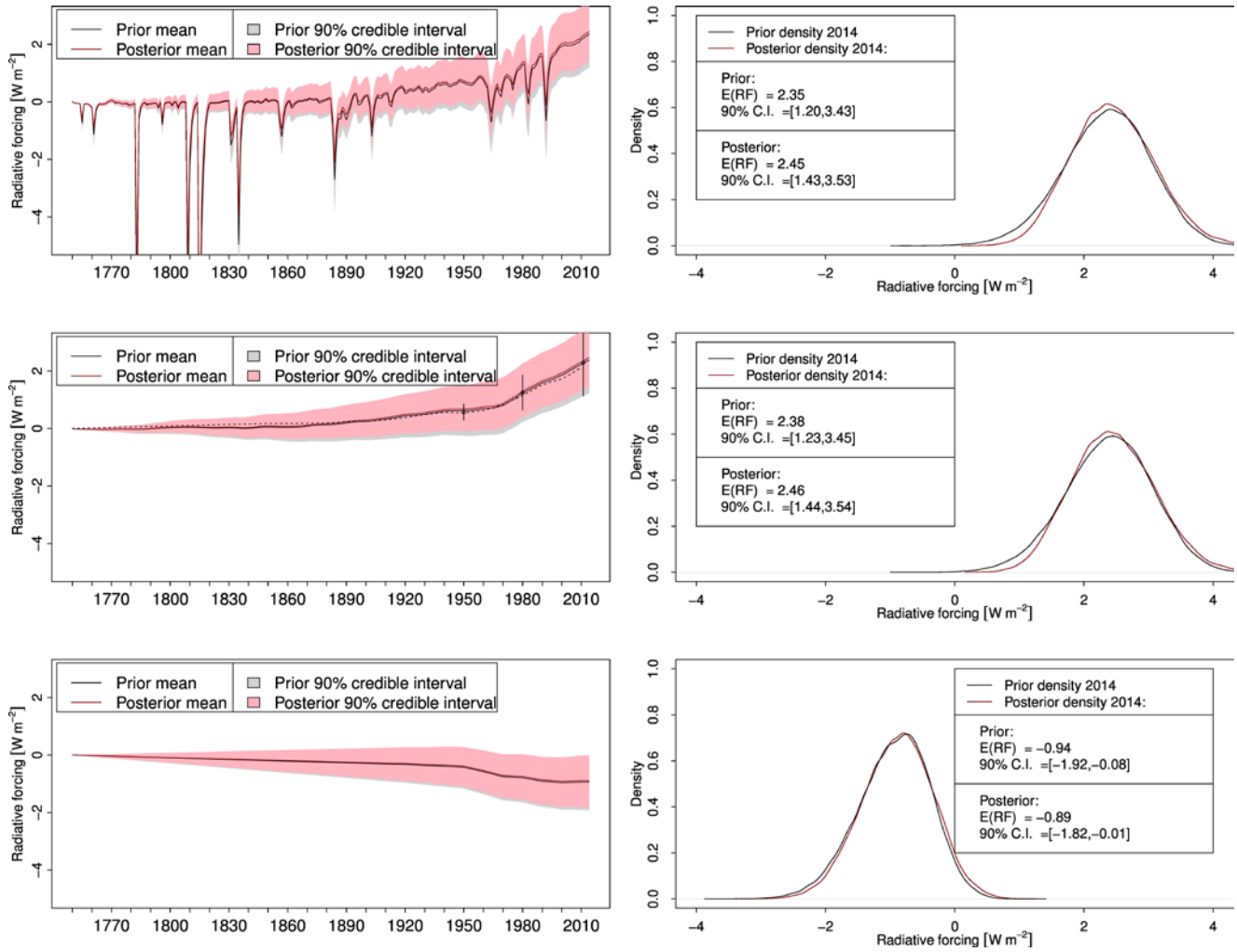
Figure S7b. As Fig S7a but for Case B and PDF of RF in 2014.
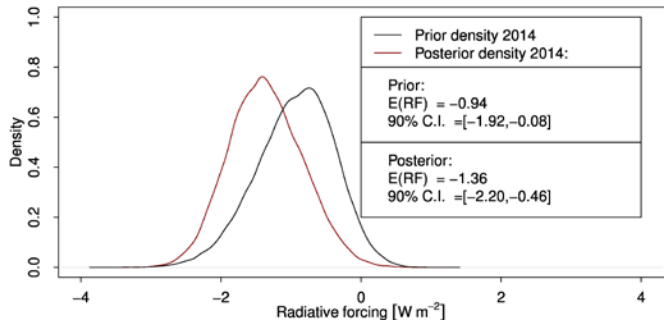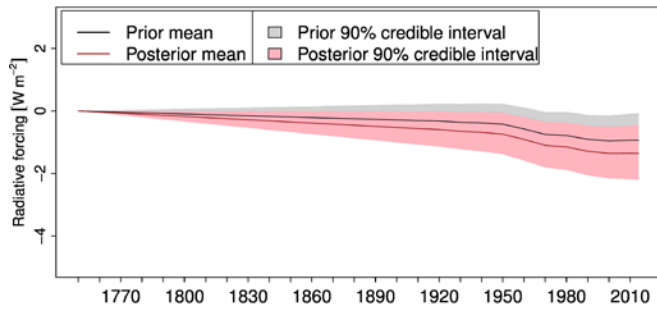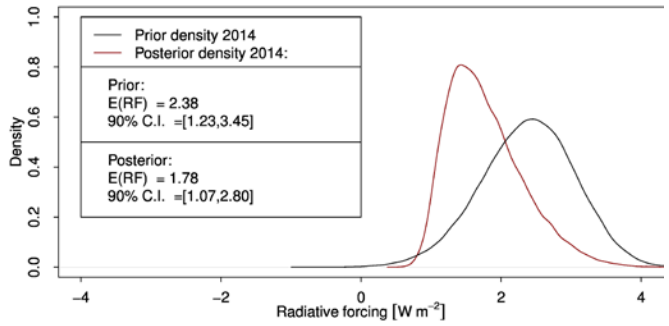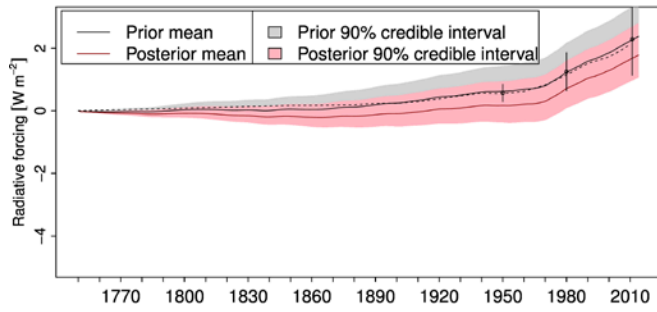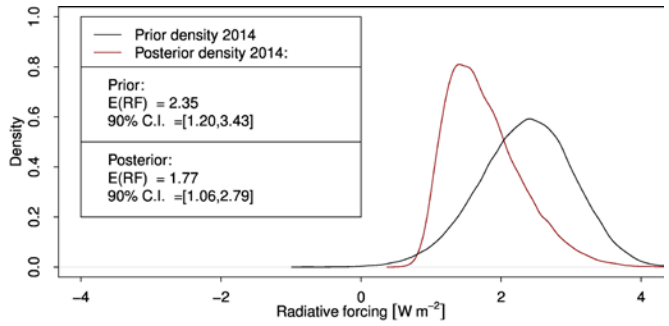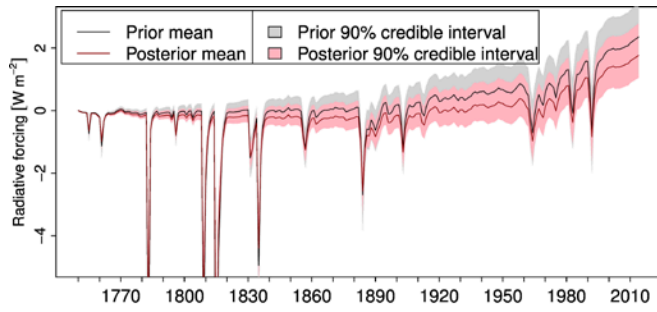
Figure S7c. As Fig S7b but for Case C.
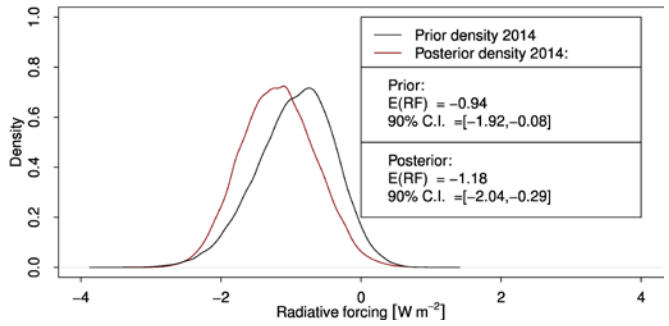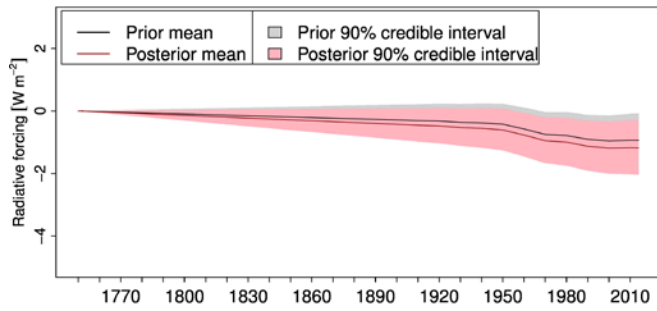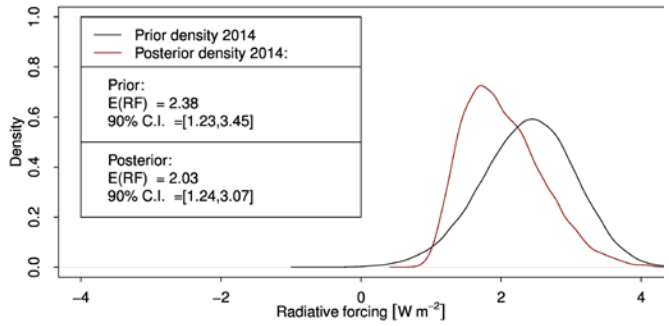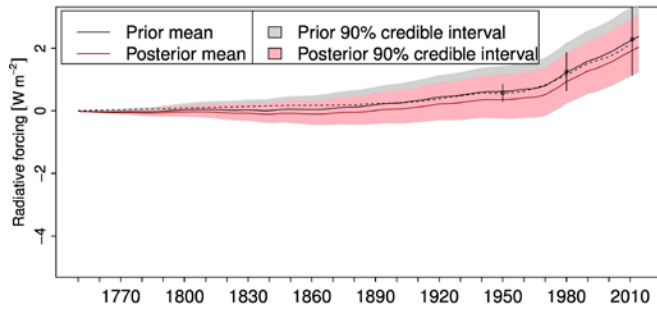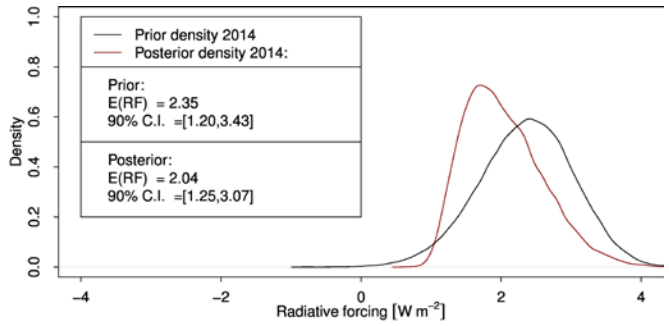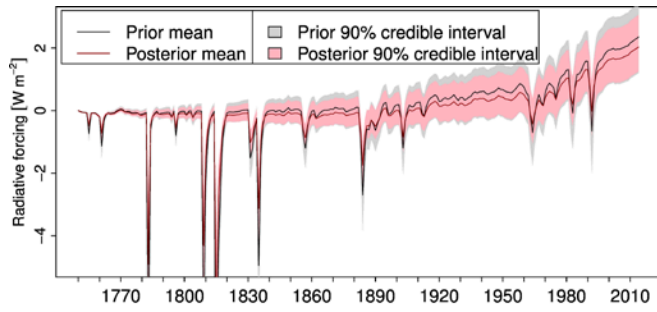
Figure S7d. As Fig S7b but for case D.
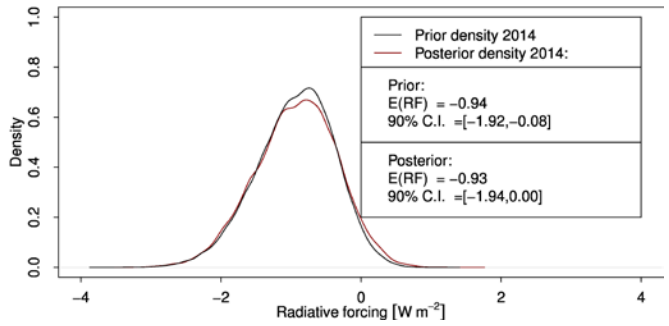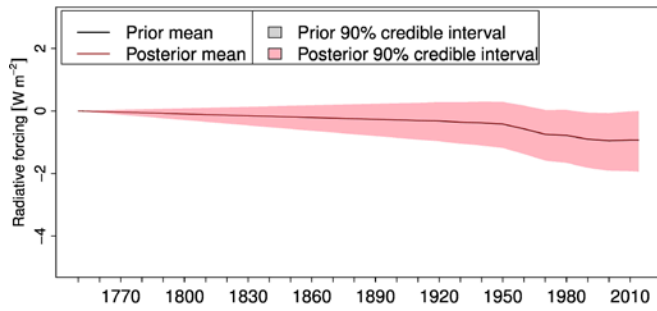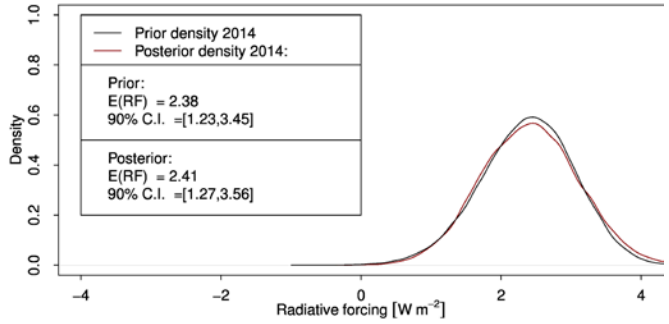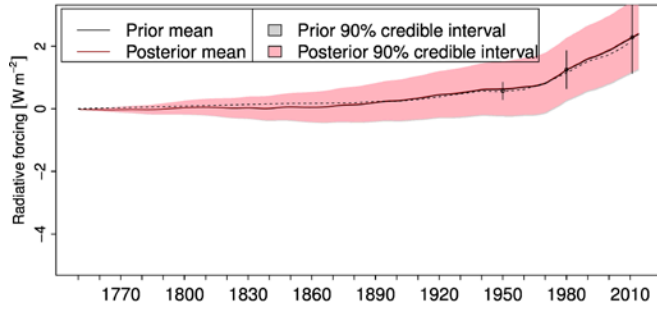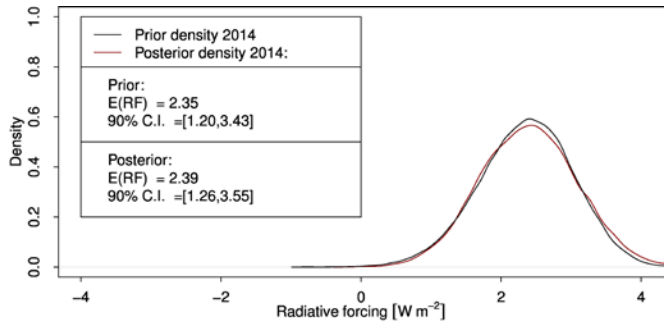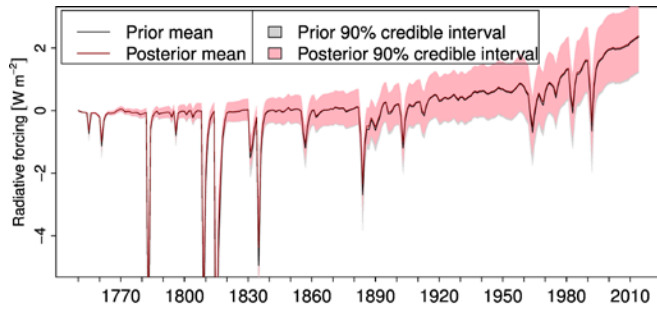
Figure S7e. As Fig S7b but for case E.
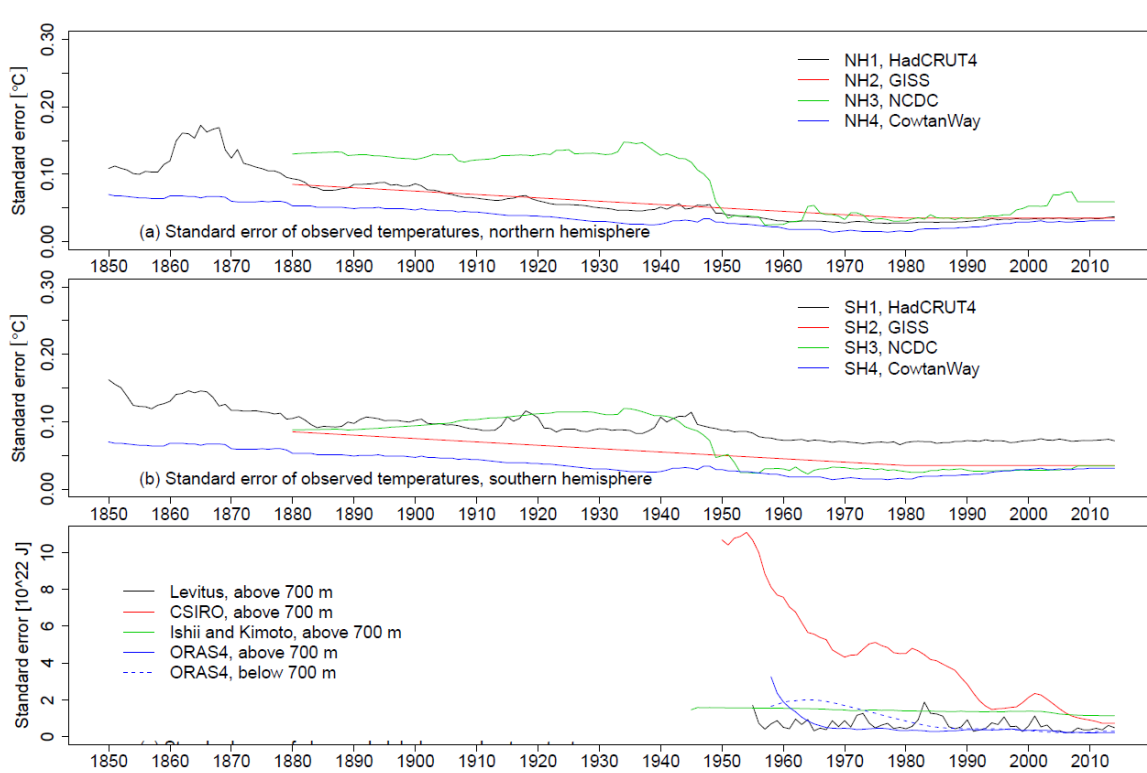
Figure S8. Reported standard errors of annual hemispheric temperature and ocean heat content data.
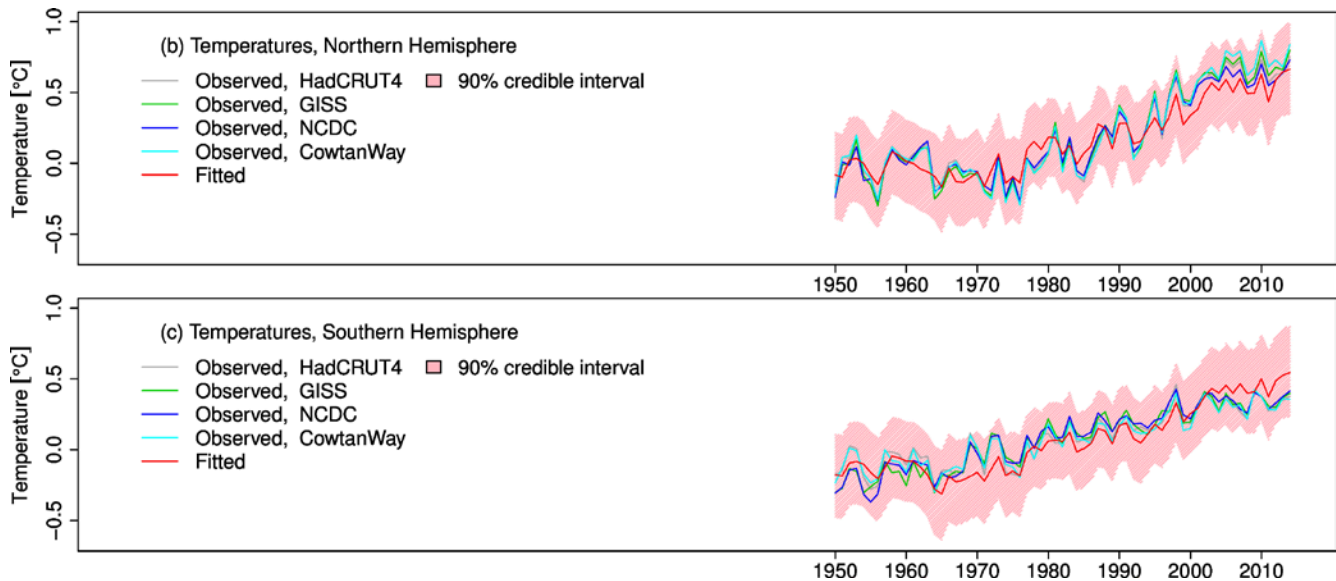
Figure S9. Observed and fitted (posterior mean) values for the hemispheric mean surface temperature series for case E (data from 1950). The shaded areas show the 90% C.I. for the sum of the output from the deterministic EBC/UDM and the term representing short-term internal natural variability (excluding the term for long-term internal natural variability and model error).

Table S1. List of forcing components included in Forc_Skeie14 and Forc_AR5

Forcing components Forc_Skeie14	Forcing components Forc_AR5
Long-lived greenhouse gases (LLGHGs)	CO_2
Tropospheric O_3	GHG Other*
Stratospheric O_3	O_3 (Tropospheric)
Stratospheric H2O from CH_4	O_3 (Stratospheric)
Direct aerosol effects: Sulphate	Aerosol (Total)
Direct aerosol effects: BC fossil fuel and biofuel (FFBF)	LUC
Direct aerosol effects: OC FFBF + secondary organic aerosols	H_2O (Stratospheric)
Direct aerosol effects: Biomass burning aerosols	BC Snow
Direct aerosol effects: Nitrate	Contrails
Cloud albedo effect	Solar irradiance
Cloud lifetime effect	Volcanoes
Semi-direct aerosol effect	
Snow albedo effect	
Land use change	
Volcanoes (3 separate series)	
Solar irradiance	