

S1 Generation of the Ghan ERFaci emulator

Ghan et al. (2013) contains a simple model for calculating a global mean ERFaci from precursor emissions. The model is tuned to replicate the output from several climate models, and includes a representation of the rapid adjustment to aerosol-cloud interactions (formerly the second indirect effect; Albrecht (1989); Boucher et al. (2013)). We use the default case, where the model is tuned to emulate CAM5 output. The model code is currently slightly too slow to be implemented directly in FAIR for its intended purposes (e.g. running several thousand ensemble members in a few minutes) but optimisation of this is an avenue for future development.

We generate 500 samples using Latin hypercube sampling of SO_x, NMVOC and primary organic matter (BC + OC) emissions. The input distributions are exponential with mean equal to the present-day (2011) emissions from RCP4.5 (SO_x = 54.2 Mt S yr⁻¹, NMVOC = 206.9 Mt yr⁻¹ and BC+OC = 45.6 Mt yr⁻¹). This ensures a wide sample range but is more densely sampled in the regions where emissions are less than in the present day, with the idea being that the RCP historical period would be more finely resolved. Each sample triplet was run through the Ghan et al. (2013) model with the ERFaci output saved. From this a functional relationship of the form

$$F_{\text{aci}} = a \log(b_1 E_{\text{SO}_x} + b_2 E_{\text{NMVOC}} + b_3 E_{\text{BC+OC}}) \quad (\text{S1})$$

was sought. This was inspired by the simple model of Stevens (2015) which depends only on SO_x emissions, and was trialled noting the response of the ERFaci curves for various different combinations of the input parameters.

The dependence on NMVOC emissions (a fraction of which generate secondary organic aerosol, SOA) is dropped as ERFaci is found to be relatively insensitive in our configuration, but also did not appear to satisfy the relationship in (S1). Dropping SOA reduces the dimensionality of the problem. We then fit a curve to the derived ERFaci using SO_x and BC+OC as predictor variables, obtaining $a = -1.95$, $b_1 = 0.0111$, $b_2 = 0$, $b_3 = 0.0139$ (fig. S1). Figure S1 also shows the ERFaci from the Ghan model for each input.

S2 Alternative prior distribution for ECS and TCR

Figure S2 details the alternative prior distributions and the posteriors obtained as a result of constraining to the C&W observed temperatures. The marginal distributions of both TCR and ECS take on a lognormal shape that is similar to the original NROY ensemble distribution (fig. 3; main manuscript), and weighted towards the lower end of the prior distributions. Under this prior distribution, the posterior modal values of ECS and TCR are about 2.1 K and 1.3 K, although the median values are somewhat higher at 2.76 and 1.64 K, and the credible ranges are wider than in NROY (in fact, wider than the AR5 *likely* ranges; table 7 in main manuscript).

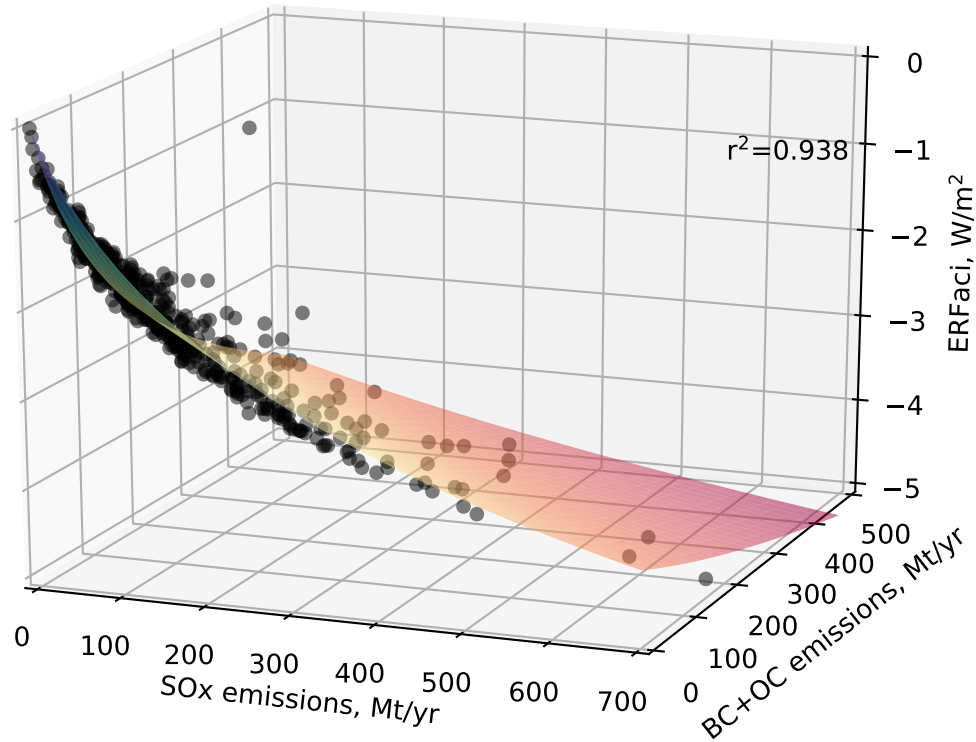


Figure S1. Comparison of the emulated ERFaci from the Ghan et al. (2013) model (coloured surface) with the values obtained from the Ghan et al. model.

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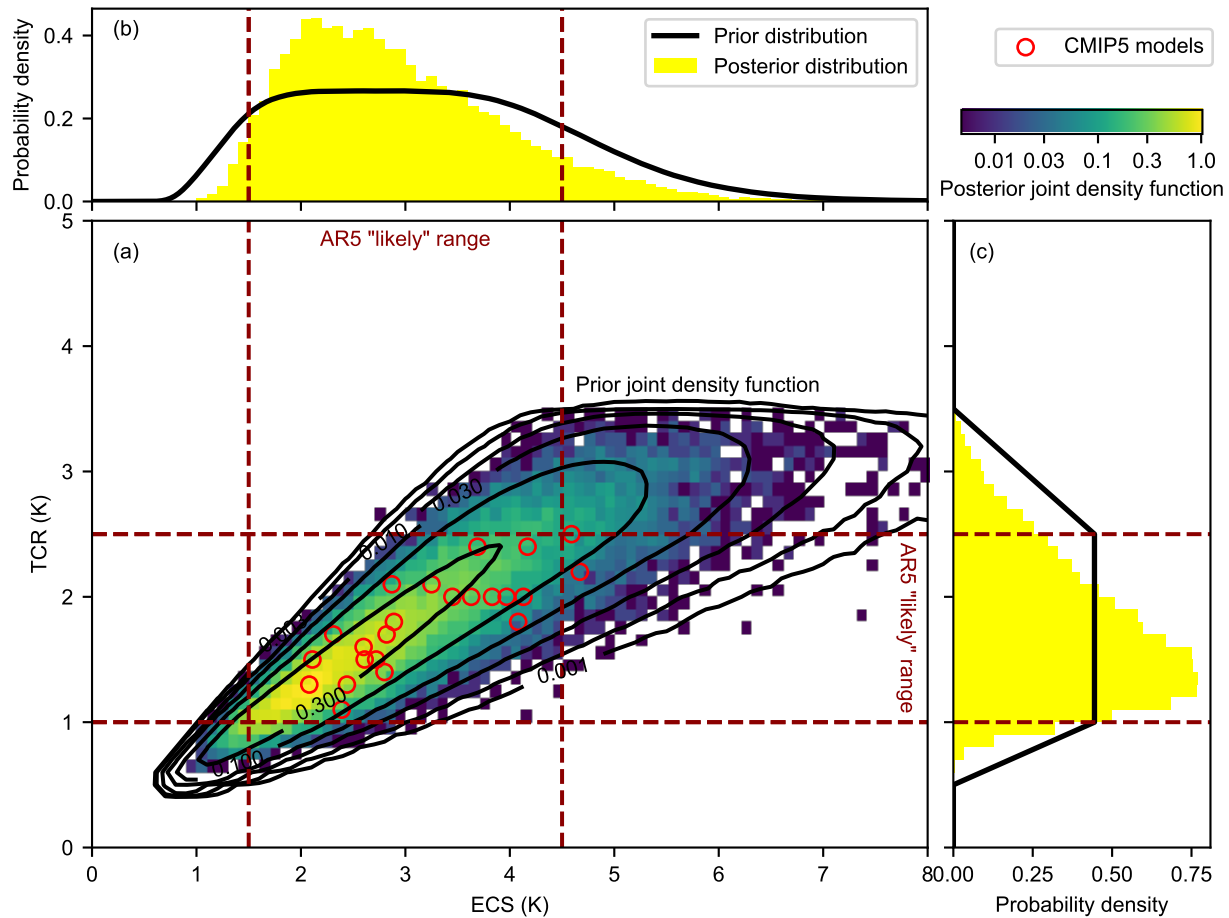


Figure S2. Prior and posterior distributions of the alternative ECS/TCR (a) joint distributions; (b) marginal ECS distributions; (c) marginal TCR distributions.