Supplementary material for: Gaps in our understanding of ice-nucleating particle sources exposed by global simulation of the UK climate model

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1 Location of Southern Ocean INP measurements

In Sect. 4.2.3 of the manuscript we compare two methods for representing marine-sourced INP. For the comparison we use measurements taken the ACE measurement campaign (Tatzelt et al., 2021) and the CAPRICORN campaign (McCluskey et al., 2018b). Figure S1 shows the coverage of these measurements throughout the Southern Ocean.

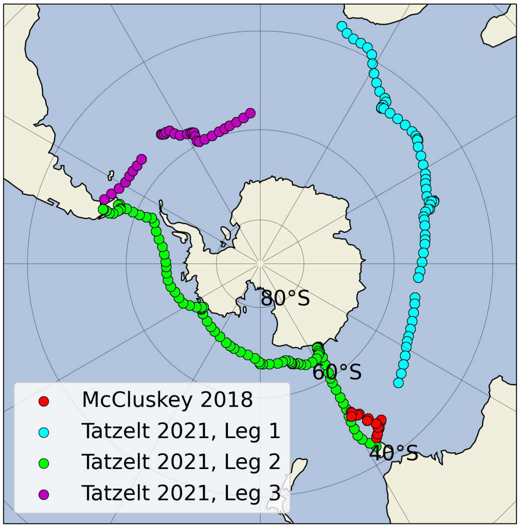

Figure S1. Location of INP measurements used to evaluate the two marine-source INP approaches. Data include measurements from Tatzelt et al. (2021) during the Antarctic Circumnavigation Expedition (ACE) in the Austral summer of 2016/17, and from McCluskey et al. (2018a) during the Clouds, Aerosols, Precipitation, Radiation, and atmospherIc Composition Over the southeRN ocean (CAPRICORN) campaign in March 2016.

2 Sensitivity of model parameterization bias for each representation of dust ice-nucleating activity

Figure S2 shows the sensitivity of the INP model to the choice of parameterization used to represent the ice-nucleating ability of dust. This is similar to Fig. 11 in the main manuscript but here we show the sensitivity of the parameterization temperature bias as a function of measurement temperature for the three methods. The figure shows using the fertile soil assumption reduces bias from 21.8 (Fig. S2b) to 17.7 (Fig. S2d) and visually reduces some of the temperature-dependent bias in the representation of INPs in the model. Figure S4 demonstrates this reduction in temperature dependence using the ΔPbias value.

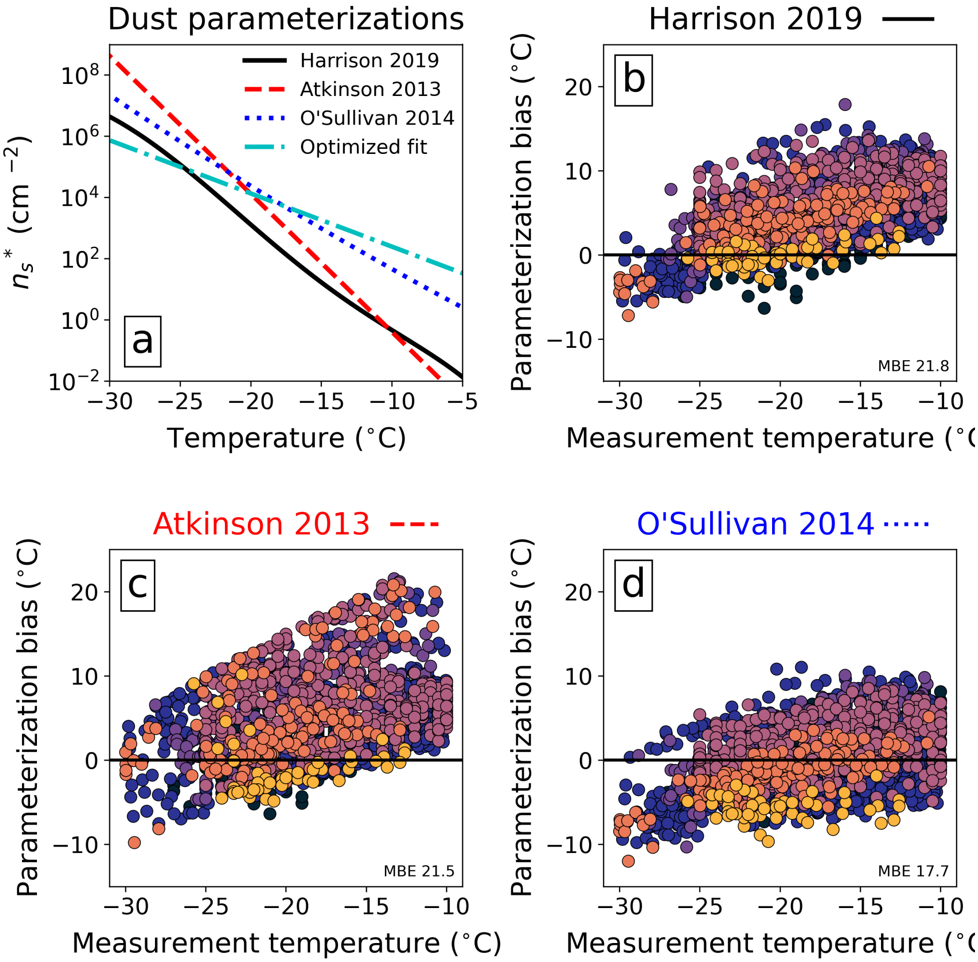

Figure S2. Sensitivity of simulated dust INP concentration to parameterizations of ice-nucleating activity. Same as Fig. 12 in manuscript but showing parameterization temperature bias. (a) temperature-dependent n_s curves of the three parameterizations, where n_s for the Harrison et al. (2019) and Atkinson et al. (2013) curves are scaled by 5% (accounting for dust K-feldspar content) to make all descriptions comparable. Panels (b), (c), and (d) show the parameterization temperature bias in the simulated N_{INP} as a function of measurement temperature in all regions for the Harrison et al. (2019), Atkinson et al. (2013), and O'Sullivan et al. (2014) parameterizations.

3 Comparing the desert soils parameterization against in-situ dust samples from desert regions

In Sects. 5.1 and 5.2 we discuss the distinction between fertile soils (that contain organic material attached to the dust) and desert soils (that are largely abiotic). Figure S3 shows that the desert soil parameterization (Harrison et al., 2019), based on a 5% K-feldspar content, compares well against airborne dust samples from desert regions. This suggests dust emissions from desert regions are well represented as desert soils, and will be poorly represented by the fertile soil parameterization.

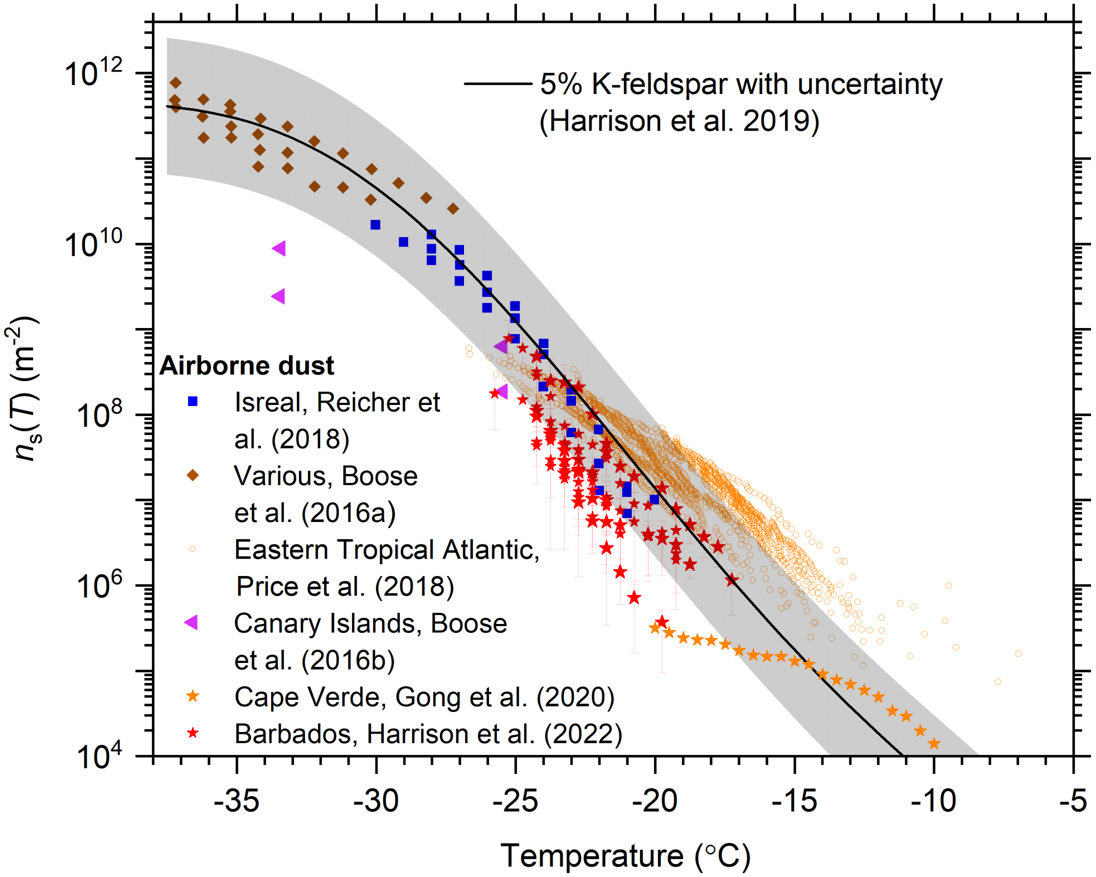

Figure S3. Ice-nucleating active site density (n_s) as a function of temperature from in-situ measurements of airborne dust samples (symbols) and a parameterization from Harrison et al. (2019) (solid line and grey shading) that assumes 5% of the dust surface area is K-feldspar. The measurements are taken from Reicher et al. (2018) (blue squares), Boose et al. (2016b) (red diamonds), Price et al. (2018) (empty circles), Boose et al. (2016a) (magenta triangles), Gong et al. (2020) (orange stars), and Harrison et al. (2022) (red triangles with uncertainty ranges). The grey shading around the solid black line represents the parameterization uncertainty.

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