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# Understanding and reducing surface biases over the Southern Ocean in the FOCI climate model

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We examine the current surface biases in sea-surface temperature (SST), sea-ice fraction, and winds over the Southern Ocean in the FOCI climate model and demonstrate various methods to reduce them. We examine and tune biases in both atmosphere-only simulations with ECHAM6 and OpenIFS 43r3 and coupled models FOCI (ECHAM6+NEMO) and FOCI-OpenIFS (OpenIFS + NEMO). Over the Southern Ocean both coupled climate models suffer from a warm SST bias, low sea-ice fraction, and surface westerlies with a maximum too far north. We explore how modifying ocean mixing parameters, air-sea coupling frequency and ice model parameters impacts surface biases.

Shortening coupling frequency in the FOCI model from 3-hourly to hourly reduces both the warm SST bias and the low sea-ice fraction bias, while the northward bias of the westerly wind maximum is largely unchanged. This suggests that the SST and sea-ice fraction biases are related to a lack of wind gustiness and not the biases in mean the winds. Similarly, reducing the horizontal tracer diffusion in the ocean from 600 m2/s to 300 m2/s also reduces the warm SST bias and the low sea-ice fraction bias. The cooling of the Southern Ocean surface is likely due to a reduced vertical heat transport by the tracer diffusion, which is along iso-neutral surfaces. Combined, both reducing the coupling frequency and re-tuning the horizontal mixing parameters acts to reduce the Southern Ocean surface biases more than either one alone.

The two coupled models, FOCI and FOCI-OpenIFS, share identical ocean model configurations, NEMO ORCA05, but produces warm SST biases in different ways. OpenIFS suffers from a strong cloud radiative forcing bias which is not existent in ECHAM. Hence, reducing the SST and sea-ice fraction biases in FOCI-OpenIFS requires improvements in the cloud scheme rather than tuning oceanic mixing parameters.