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Revisiting the relationship between dynamical sensitivity and climate sensitivity in the Southern hemisphere

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The Southern Annular Mode (SAM) is the dominant mode of midlatitude atmospheric circulation variability in the Southern hemisphere. In the future, the SAM trend is expected to be the net result of opposing effects from increasing greenhouse gases (GHG) and ozone recovery. Different greenhouse gas scenarios, which induce different rates of surface and atmospheric temperature change, are therefore associated with different future SAM trends (Barnes et al., 2014). Since the magnitude of warming due to GHGs is an important component of this response, one might expect to find a relationship between equilibrium climate sensitivity (ECS) and future Southern hemisphere circulation trends. In CMIP5, the relationship between the SAM and the level of tropospheric warming across models was found to be strongest in the summer and autumn and could explain around 20% of the intermodel spread (Grise and Polvani, 2014). The spread is more strongly correlated with differences in meridional temperature gradients (Harvey et al., 2014).

Many of the latest CMIP6 models show a larger equilibrium climate sensitivity (ECS) of up to ~5.5 K (Forster et al., 2019) compared to a maximum of ~4.7 K in CMIP5. This raises the important question of how a higher level of warming affects projections of the SH midlatitude circulation. In this study, we examine the response of the SAM in CMIP6 models and quantify its relationship to ECS and temperature gradients. Our starting hypothesis is that stronger surface warming will induce a larger increase in tropical free tropospheric temperatures, and hence all being equal, a larger tropics-to-pole temperature gradient and a more positive SAM trend. However, results show that despite the higher level of warming in the CMIP6 models, there is a smaller positive trend in SAM index than in CMIP5 indicating a different relationship between warming and midlatitude circulation trends in CMIP6. We attempt to explain potential reasons for these differences.

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