Supplementary Information: Examining the impact of multiple climate forcings on simulated Southern Hemisphere climate variability

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Contains:

Fig. S1 Linear trends (per decade) SH SIC for the austral spring (top panel) and autumn (bottom panel) for the period spanning 1971-2015, both from the Earth System Model (ESM, a,c) simulations and the Climate of Twentieth Century (C20C, Folland et al. 2002; Rayner et al. 2003) obtained from the Coupled Model Intercompariosn Project Phase Five (CMIP5) archive (b,d). Regions with statistically significant trends at 95% are indicated with stippling. The linear trends are estimated using the non-parametric Mann-Kendall and Sen's methods (Hamed and Ramachandra Rao 1998; Gocic and Trajkovic 2013).

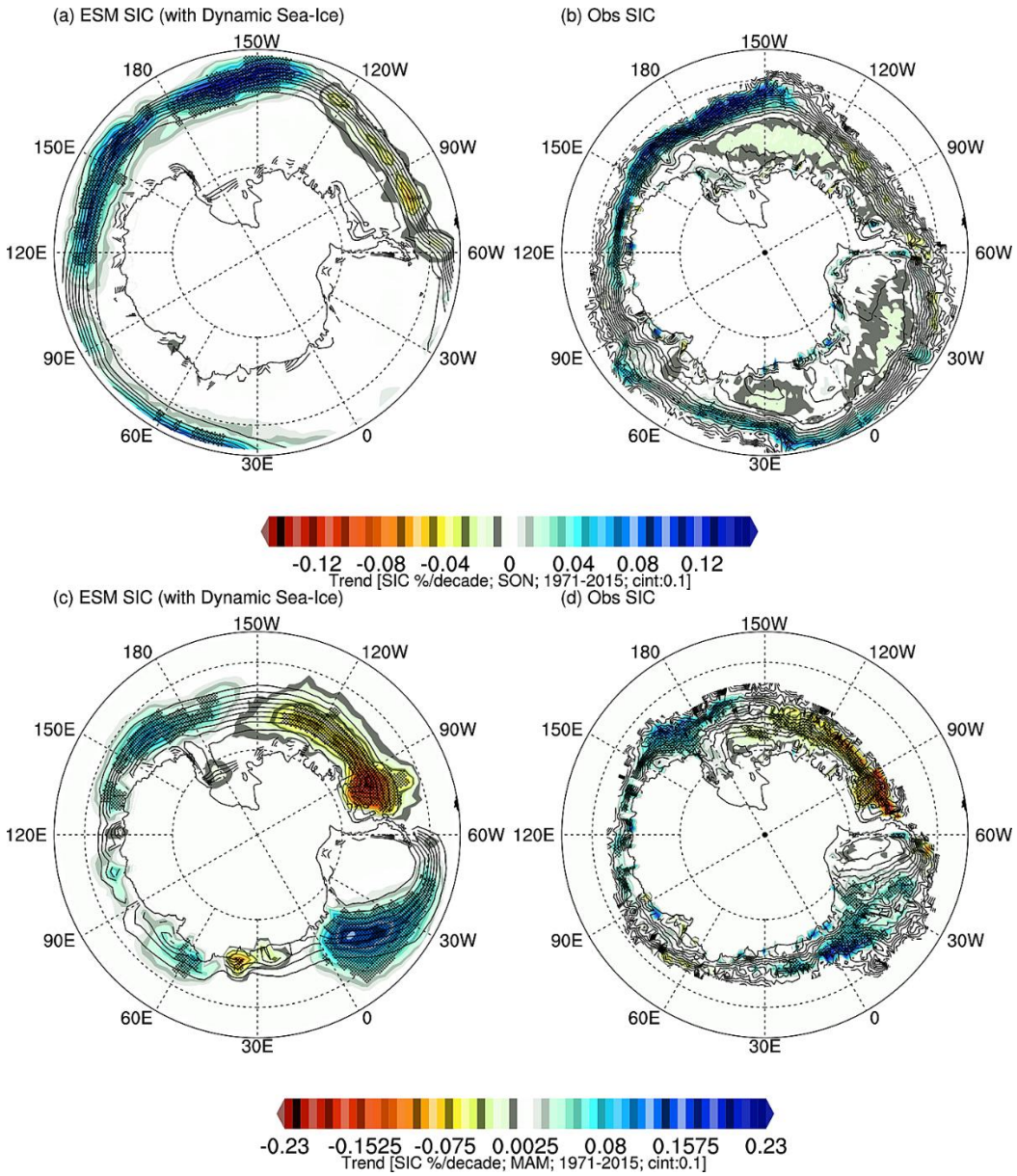
Fig. S2 Simulated (a-d) and observed (e,f) linear trends of SH mid- and high-latitude 850mb geopotential height (GH) m/decade during the austral winter. The National Centers for

Environmental Prediction (NCEP) Reanalysis (R2) dataset (Kanamitsu et al. 2002) and the 20th Century Reanalysis (20CR, Compo et al. 2008, 2011) are used as a proxy for observation. Regions with statistically significant trends at 95% are indicated with stippling.

Fig. S3 As Fig. S2 but for 500mb GH.

Fig. S4 ESM actual skill and level of accuracy simulating observed SH SST using mean-square skill score (MSSS; Murphy 1988; top panel) and RMSE (bottom panel) respectively for the four main seasons. Regions with statistically significant MSSS at 95% are indicated with stippling. The significance test has been performed using bootstrap none parametric technique (resampling with replacement for 1000x; Wilks 2006).

References



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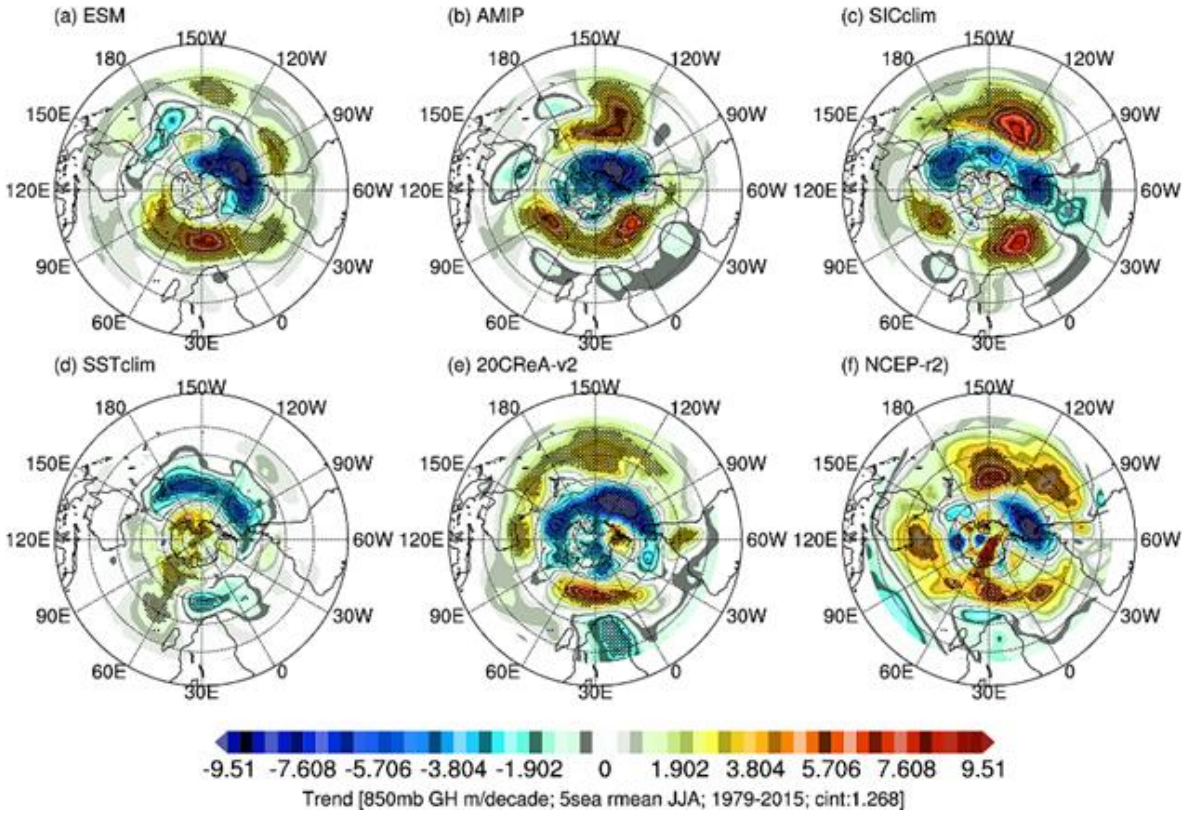

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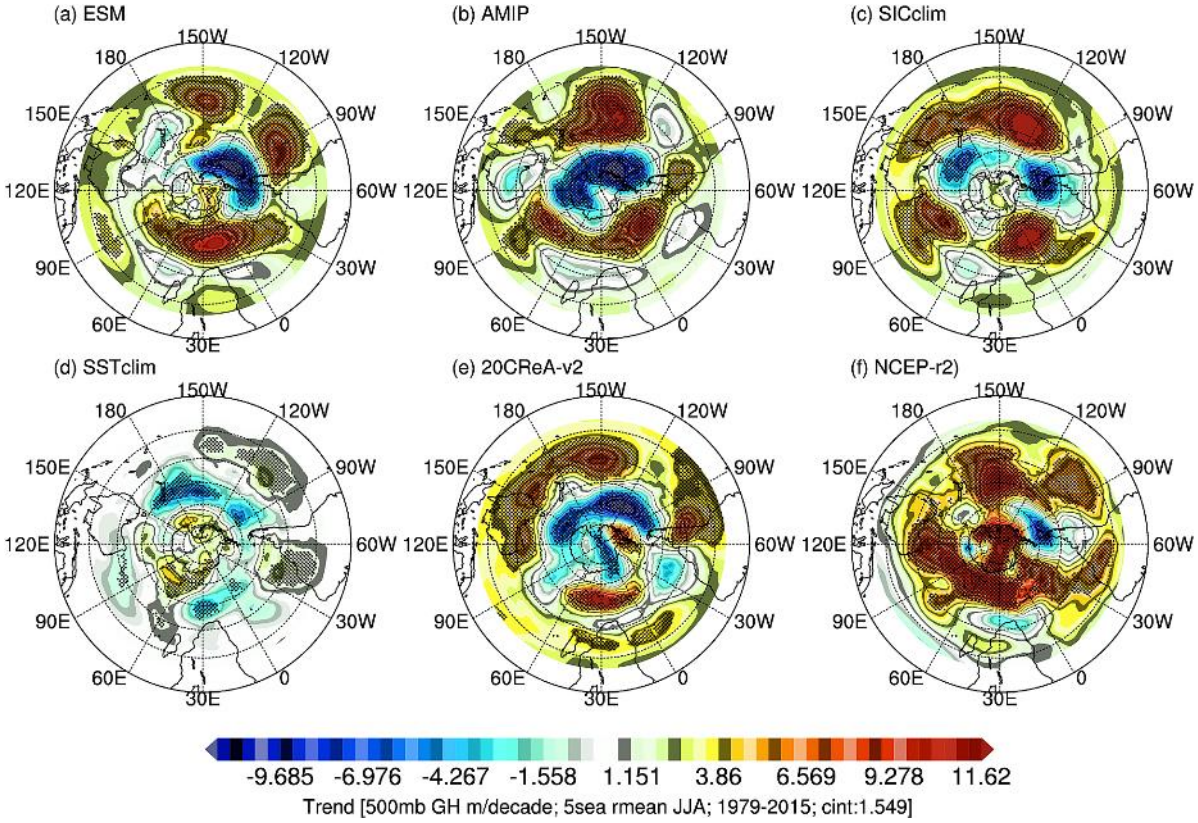

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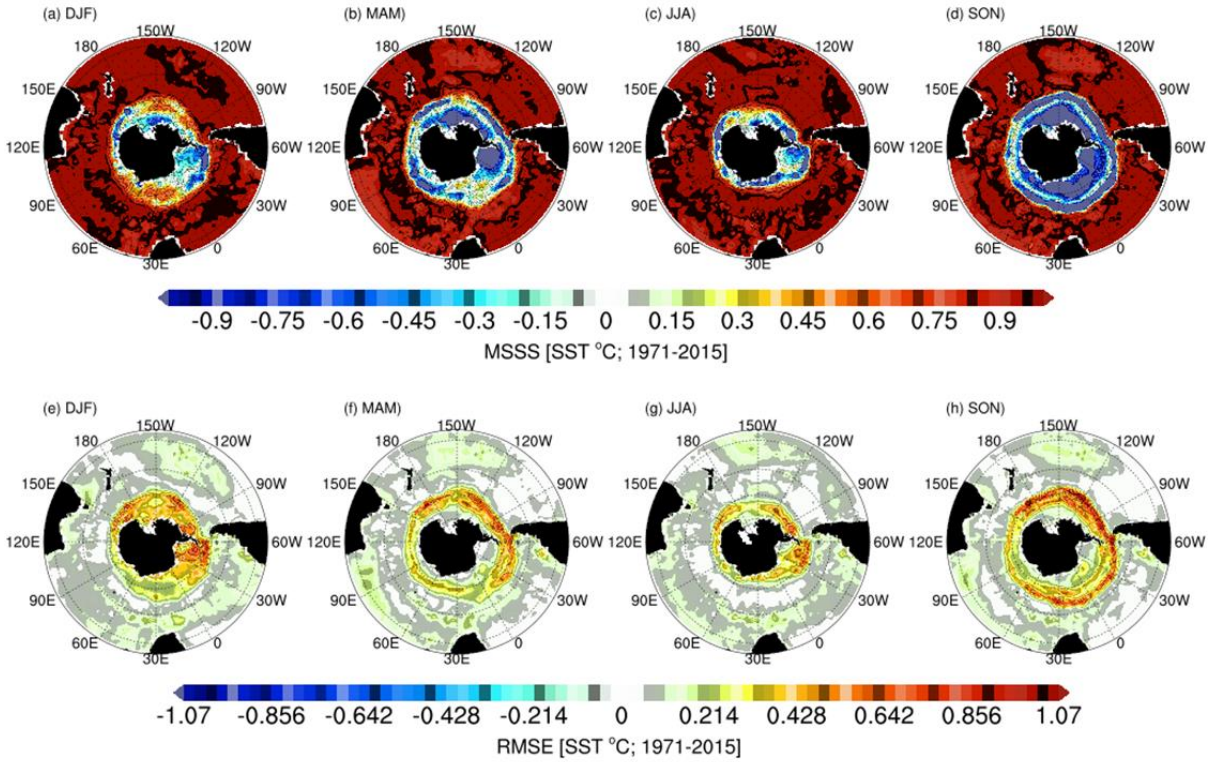

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References

Compo GP, Whitaker JS, Sardeshmukh PD et al (2011) The twentieth century reanalysis project. Q J R Meteorol Soc. https://doi.org/10.1002/qj.776

Compo GP, Whitaker JS, Sardeshmukh PD (2008) The 20th Century Reanalysis Project. In: Third WCRP International Conference on Reanalysis, The University of Tokyo, Japan. 28 Jan–1 Feb 2008

Folland C, Shukla J, Kinter J, Mark R (2002) The climate of the twentieth century project. CLIVAR Exch No. 65 V. 19 (2): 37–39.

Gocic M, Trajkovic S (2013) Analysis of changes in meteorological variables using Mann-Kendall and Sen's slope estimator statistical tests in Serbia. Glob Planet Change. doi: 10.1016/j.gloplacha.2012.10.014

Hamed KH, Ramachandra Rao A (1998) A modified Mann-Kendall trend test for autocorrelated data. J Hydrol. doi: 10.1016/S0022-1694(97)00125-X

Kanamitsu M, Ebisuzaki W, Woollen J, et al (2002) NCEP-DOE AMIP-II reanalysis (R-2). Bull Am Meteorol Soc. doi: 10.1175/BAMS-83-11-1631(2002)083<1631:NAR>2.3.CO;2

Murphy AH (1988) Skill scores based on the mean square error and their relationships to the correlation coefficient. Mon Weather Rev. doi: 10.1175/1520-

0493(1988)116<2417:SSBOTM>2.0.CO;2

Rayner NA, Parker DE, Horton EB, et al (2003) Globally complete analyses of sea surface temperature, sea ice and night marine air temperature, 1871-2000. J Geophys Res. doi: 10.1029/2002JD002670