

Supporting Information for ‘Large sampling uncertainty when diagnosing the ‘eddy feedback parameter’ and its role in the signal-to-noise paradox’’

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Additional Supporting Information (Files uploaded separately)

1. Caption for large table S6 (uploaded as separate excel file)

Introduction The supporting information in this document includes a comparison of using different pressure levels to calculate the EFP (Fig. S1), maps of barotropic energy

generation rate for each model and ERA5 (Fig. S2), various estimates of NAO variance from different reanalysis datasets (Figs. S3 and S4), the caption for Table S1 uploaded separately, and the full results of the linear regressions from Figs. 3 and 4 (Tables S2-S6).

Table S1. Table S6 shows the CMIP6 historical simulations used in this study listed by model and variant, as well as the calculated EFP, NAO variance, multidecadal NAO variance, and G_{NA} for each simulation.

References

- Hardiman, S. C., Dunstone, N. J., Scaife, A. A., Smith, D. M., Comer, R., Nie, Y., & Ren, H.-L. (2022). Missing eddy feedback may explain weak signal-to-noise ratios in climate predictions. *npj Clim. Atmos. Sci.*, 5(1), 57. Retrieved from <https://doi.org/10.1038/s41612-022-00280-4> doi: 10.1038/s41612-022-00280-4
- Smith, D. M., Eade, R., Andrews, M. B., Ayres, H., Clark, A., Chripko, S., ... Walsh, A. (2022). Robust but weak winter atmospheric circulation response to future Arctic sea ice loss. *Nat. Commun.*, 13(1), 727. Retrieved from <https://doi.org/10.1038/s41467-022-28283-y> doi: 10.1038/s41467-022-28283-y

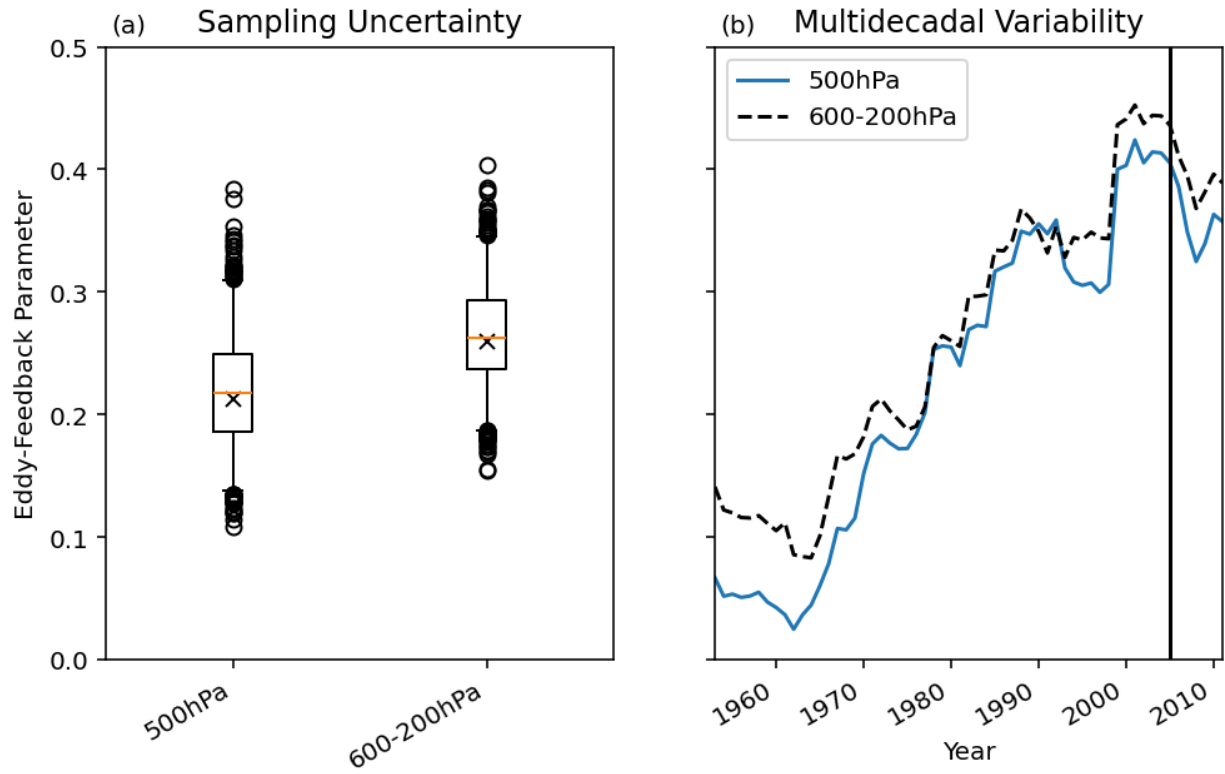


Figure S1. Uncertainties in the EFP calculation in ERA5 for (a) sampling and (b) multidecadal variability, calculated in the same way as Fig. 2 but comparing averaging r^2 at 500 hPa (following Hardiman et al. (2022)) and averaging r^2 from 600-200 hPa (following Smith et al. (2022)), here using data at every 50 hPa. The 600-200 hPa average generally shows larger EFP but similar uncertainty.

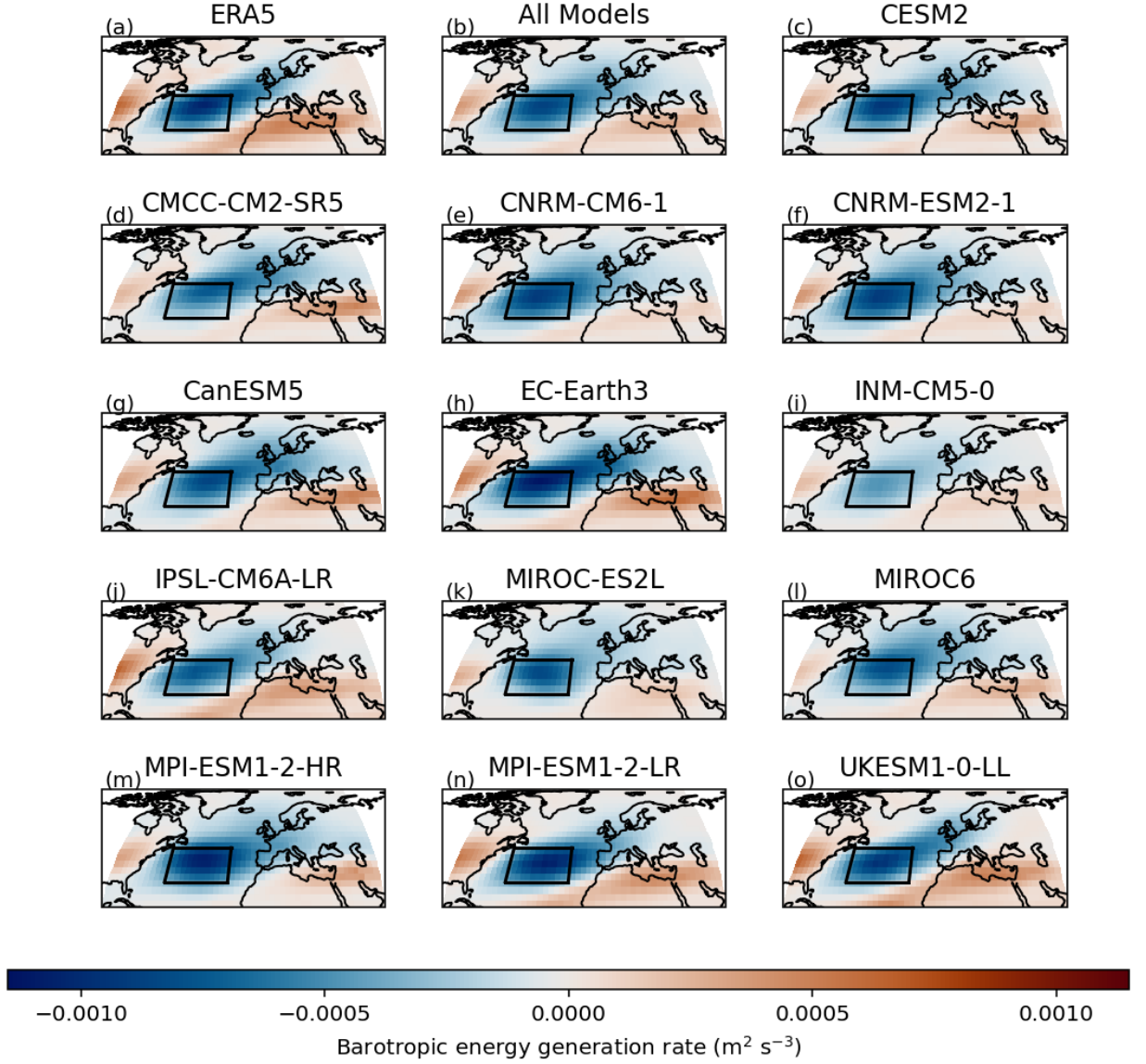


Figure S2. The DJF mean barotropic energy generation rate (G) for (a) ERA5 (1940-2022), (b) CMIP6 multi-model mean for historical simulations (1850-2014) and (c)-(o) CMIP6 ensemble mean for each model for historical simulations. The black box in each figure covers 60°–25°W, 30°–45°N and is the averaging region used in the main paper to reduce G to a single number, G_{NA} . The box is designed to capture the regional minimum while excluding positive regions to avoid cancellation.

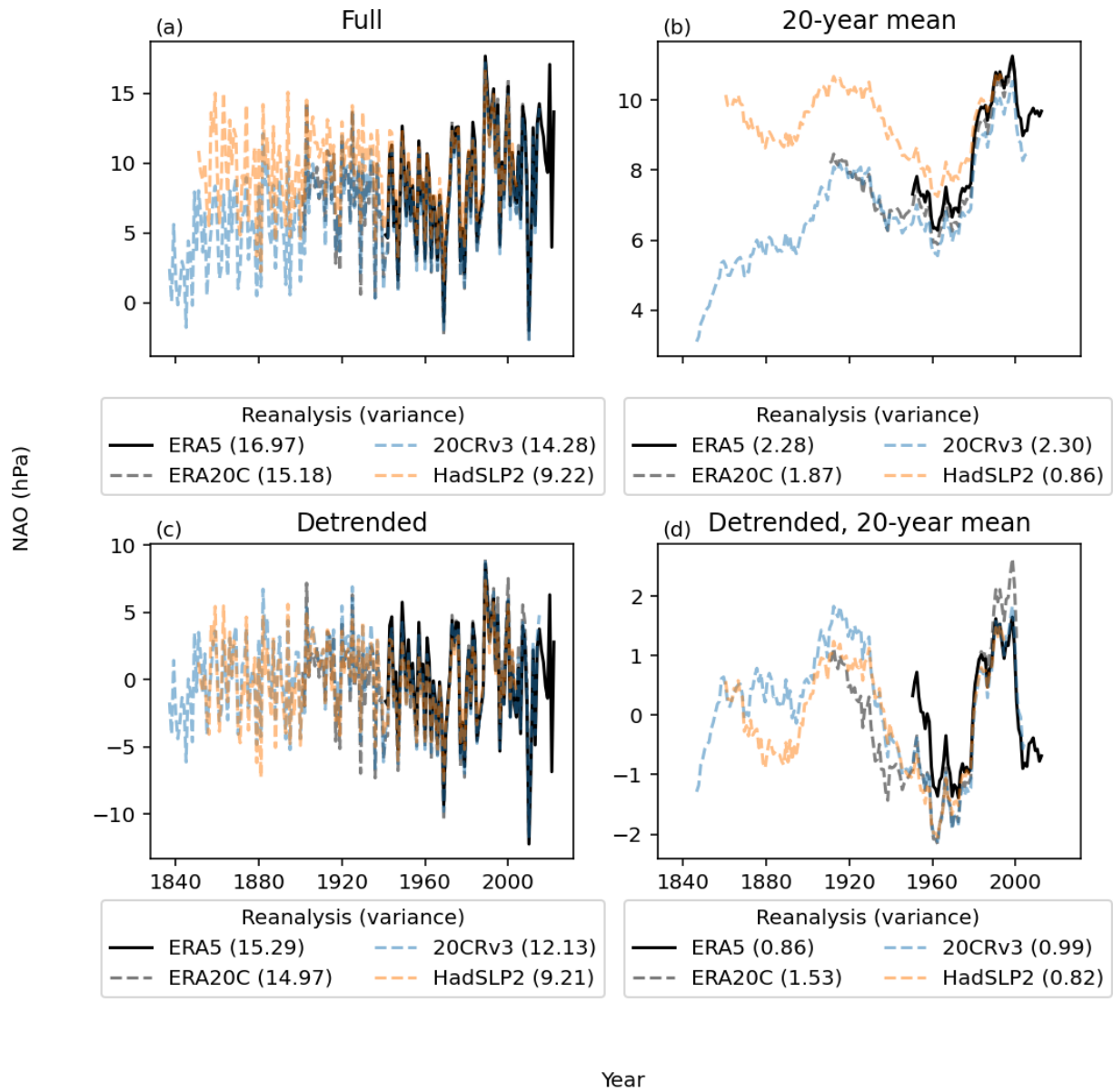


Figure S3. Timeseries of the NAO (a, b) and 20-year running mean NAO (c, d) calculated using different reanalysis datasets, and the influence of detrending these timeseries (c, d). The numbers in each panel show the NAO variance for the timeseries in that panel for each dataset.

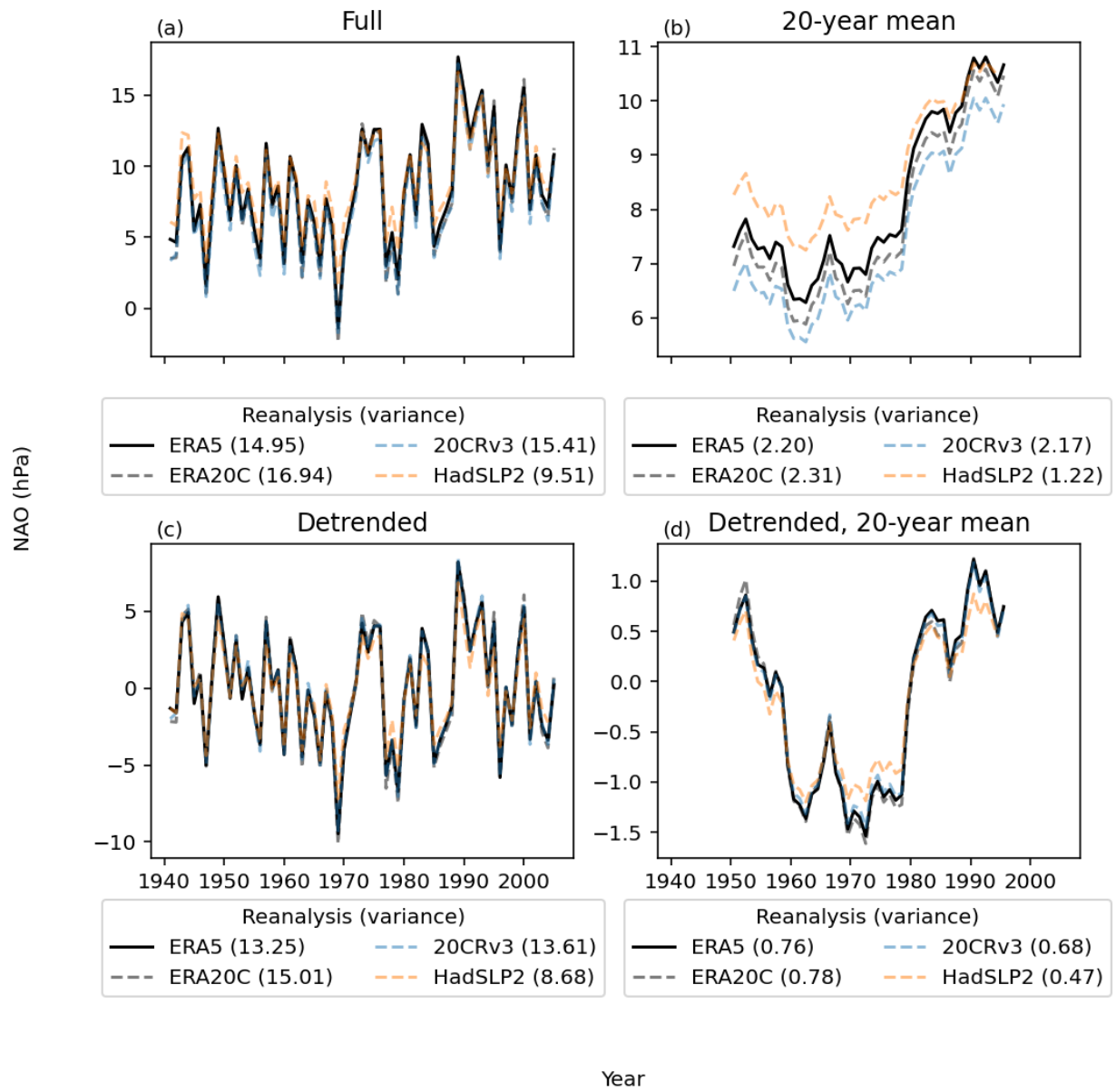


Figure S4. The same as Fig. S3, but only using data in the period that is common to all reanalyses (1900-2010).

Table S2. Linear regression results for EFP vs. total NAO variance.

	Slope	Intercept	Correlation	p-value
ERA5	28.83	10.49	0.55	6.7e-79
CESM2	7.22	20.10	0.05	0.89
CMCC-CM2-SR5	0.75	16.52	0.015	0.97
CNRM-CM6-1	55.62	8.09	0.5	0.0052
CNRM-ESM2-1	30.97	12.56	0.51	0.13
CanESM5	36.69	4.83	0.68	7.8e-06
INM-CM5-0	15.27	9.24	0.57	0.082
IPSL-CM6A-LR	74.84	4.67	0.63	7.7e-05
MIROC-ES2L	5.57	6.18	0.16	0.4
MIROC6	31.62	4.55	0.71	0.022
MPI-ESM1-2-HR	-53.21	29.09	-0.49	0.15
MPI-ESM1-2-LR	37.47	8.90	0.42	0.026
UKESM1-0-LL	26.34	7.35	0.56	0.019
Mean	30.10	8.86	0.37	0.24
All	30.53	8.92	0.34	8.1e-08
Weighted	31.68	8.81	0.42	-

Table S3. Linear regression results for EFP vs. mulitdecadal NAO variance.

	Slope	Intercept	Correlation	p-value
CESM2	-2.44	1.52	-0.14	0.7
CMCC-CM2-SR5	6.50	-1.50	0.42	0.19
CNRM-CM6-1	-2.33	1.23	-0.12	0.54
CNRM-ESM2-1	2.91	0.17	0.42	0.23
CanESM5	1.68	0.24	0.19	0.28
INM-CM5-0	1.62	0.19	0.17	0.64
IPSL-CM6A-LR	2.24	0.27	0.18	0.33
MIROC-ES2L	0.63	0.20	0.12	0.52
MIROC6	-0.46	0.51	-0.074	0.84
MPI-ESM1-2-HR	0.63	0.49	0.02	0.96
MPI-ESM1-2-LR	6.24	-0.62	0.36	0.057
UKESM1-0-LL	0.41	0.52	0.039	0.88
Mean	1.21	0.37	0.39	0.21
All	1.37	0.35	0.22	0.0006
Weighted	1.53	0.27	0.14	-

Table S4. Linear regression results for G_{NA} vs. total NAO variance.

	Slope	Intercept	Correlation	p-value
ERA5	8461.79	22.42	0.073	0.022
CESM2	131289.14	106.14	0.38	0.28
CMCC-CM2-SR5	8617.46	20.90	0.14	0.68
CNRM-CM6-1	-14521.78	7.82	-0.14	0.47
CNRM-ESM2-1	20153.73	31.97	0.23	0.52
CanESM5	-36974.19	-5.57	-0.24	0.16
INM-CM5-0	40523.43	26.54	0.65	0.04
IPSL-CM6A-LR	43468.05	45.39	0.23	0.2
MIROC-ES2L	-4334.54	4.68	-0.07	0.71
MIROC6	-23431.50	-2.09	-0.31	0.38
MPI-ESM1-2-HR	-16241.35	3.40	-0.3	0.41
MPI-ESM1-2-LR	29384.11	40.07	0.39	0.042
UKESM1-0-LL	28850.67	33.41	0.35	0.17
Mean	-9590.76	10.03	-0.28	0.38
All	-7204.36	11.55	-0.16	0.015
Weighted	10707.70	22.47	0.075	-

Table S5. Linear regression results for G_{NA} vs. multidecadal NAO variance.

	Slope	Intercept	Correlation	p-value
CESM2	2963.38	2.70	0.069	0.85
CMCC-CM2-SR5	-7903.51	-3.10	-0.44	0.18
CNRM-CM6-1	1225.89	1.68	0.065	0.73
CNRM-ESM2-1	-2613.77	-1.18	-0.26	0.46
CanESM5	271.12	0.89	0.011	0.95
INM-CM5-0	11251.15	4.46	0.5	0.14
IPSL-CM6A-LR	-613.47	0.46	-0.03	0.87
MIROC-ES2L	-547.56	0.00	-0.061	0.75
MIROC6	557.26	0.72	0.053	0.88
MPI-ESM1-2-HR	4283.84	4.08	0.27	0.45
MPI-ESM1-2-LR	167.79	0.95	0.011	0.95
UKESM1-0-LL	3939.05	3.28	0.21	0.42
Mean	-467.55	0.37	-0.36	0.25
All	-551.83	0.33	-0.18	0.0067
Weighted	678.36	1.08	0.021	-

Table S6. Linear regression results for G_{NA} vs. EFP.

	Slope	Intercept	Correlation	p-value
ERA5	-8.08	0.21	-0.0037	0.91
CESM2	-79.61	0.24	-0.033	0.93
CMCC-CM2-SR5	-1009.61	-0.15	-0.86	0.00073
CNRM-CM6-1	-262.64	-0.01	-0.27	0.14
CNRM-ESM2-1	-357.42	-0.08	-0.25	0.49
CanESM5	-4.72	0.29	-0.0017	0.99
INM-CM5-0	174.96	0.26	0.075	0.84
IPSL-CM6A-LR	357.42	0.42	0.22	0.22
MIROC-ES2L	157.37	0.27	0.09	0.64
MIROC6	44.54	0.23	0.026	0.94
MPI-ESM1-2-HR	-0.31	0.24	-0.00062	1
MPI-ESM1-2-LR	204.11	0.39	0.24	0.22
UKESM1-0-LL	-160.93	0.14	-0.09	0.73
Mean	65.74	0.27	0.16	0.62
All	90.96	0.29	0.18	0.0059
Weighted	-7.83	0.23	-0.019	-