



Supplement of

The American monsoon system in HadGEM3 and UKESM1

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Supplement.

Table S1. Summary of the CMIP6 simulations in this study. For each simulation the acronym used hereafter, the experiment and the horizontal resolution are shown. The first 100 years of the piControl simulations are used and for historical experiments the period 1979-2014 is used.

	Experiment	Resolution	Acronym	Reference	
Model					
Hadley Centre Global Environment	Pre-industrial control	N96 1.875°x1.25°	GC3.1 N96-pi	(Menary et al., 2018;	
Model version 3 (HadGEM3)				Ridley et al., 2018)	
HadGEM3	Pre-industrial control	N216 $0.83^{\circ}x0.56^{\circ}$	GC3 N216-pi	(Menary et al., 2018;	
				Ridley et al., 2019c)	
HadGEM3	Historical	N96 1.875°x1.25°	GC3-hist	(Andrews et al., 2020;	
				Ridley et al., 2019b)	
HadGEM3	Atmospheric Model Inter-	N96 1.875°x1.25°	GC3-AMIP	(Ridley et al., 2019a)	
	comparison (AMIP)				
United Kingdom Earth System	Pre-industrial control	$1.875^{\circ} x 1.25^{\circ}$	UKESM-pi	(Tang et al., 2019b)	
Model version 1 (UKESM1)					
UKESM1	Historical	$1.875^{\circ} x 1.25^{\circ}$	UKESM-hist	(Tang et al., 2019a)	

Table S2. Root-mean square error (RMSE) and pattern correlation coefficients (PCC) for each season and each model experiment. Near surface air temperature (t2m), wind components (u and v) and mean-sea level pressure (mslp) are assessed against ERA-5 and precipitation (pr) against TRMM.

	Model experiment	DJF	DJF	MAM	MAM	JJA	JJA	SON	SON
Variable		RMSE	PCC	RMSE	PCC	RMSE	PCC	RMSE	PCC
t2m	GC3 N96	1.28	0.98	1.3	0.96	1.38	0.96	1.31	0.96
t2m	GC3 N216	1.05	0.99	1.07	0.98	1.02	0.98	0.98	0.98
t2m	GC3 Hist	2.06	0.94	1.75	0.93	1.73	0.94	2.05	0.92
t2m	UKESM-hist	2.03	0.94	1.77	0.93	1.8	0.94	2.0	0.93
t2m	GC3 AMIP	1.17	0.98	1.12	0.97	1.2	0.97	1.2	0.97
u	GC3 N96	0.78	0.99	0.59	0.99	0.9	0.98	0.87	0.98
u	GC3 N216	0.78	0.99	0.59	0.99	0.9	0.98	0.87	0.98
u	GC3 Hist	1.02	0.98	1.04	0.97	0.92	0.98	0.84	0.98
u	UKESM-hist	1.04	0.98	1.01	0.97	0.91	0.98	0.82	0.98
u	GC3 AMIP	0.96	0.98	0.77	0.99	1.18	0.97	1.09	0.96
V	GC3 N96	0.75	0.93	0.66	0.93	0.65	0.95	0.59	0.94
V	GC3 N216	0.6	0.96	0.5	0.95	0.57	0.96	0.54	0.94
V	GC3 Hist	0.76	0.94	0.72	0.92	0.66	0.95	0.59	0.94
v	UKESM-hist	0.75	0.93	0.69	0.92	0.65	0.95	0.6	0.93
V	GC3 AMIP	0.67	0.95	0.52	0.95	0.68	0.94	0.61	0.93
mslp	GC3 N96	1.33	0.96	1.03	0.97	1.15	0.96	0.95	0.97
mslp	GC3 N216	1.11	0.97	0.9	0.97	1.1	0.96	0.89	0.97
mslp	GC3 Hist	1.31	0.97	1.12	0.96	1.08	0.96	0.94	0.97
mslp	UKESM-hist	1.4	0.97	1.15	0.96	1.14	0.95	0.99	0.97
mslp	GC3 AMIP	1.15	0.97	0.87	0.97	1.09	0.96	0.93	0.97
pr	GC3 N96	2.02	0.79	2.24	0.71	1.62	0.9	1.69	0.86
pr	GC3 N216	1.58	0.88	1.72	0.85	1.4	0.93	1.57	0.89
pr	GC3 Hist	2.05	0.78	2.49	0.64	1.69	0.88	1.69	0.86
pr	UKESM-hist	1.96	0.8	2.39	0.66	1.71	0.88	1.62	0.87
pr	GC3 AMIP	1.42	0.9	1.61	0.88	1.95	0.88	1.8	0.88



Figure S1. Longitude-pressure level plots of the mean DJF (a, b) specific humidity (color contours) and zonal and vertical velocities (vectors) in ERA5. (a) is latitudinally averaged in 5-0°S and (b) in 0-5°N. (c, d, e, f, g, h) show the bias in vertical velocity (color-contours), zonal wind (vectors) and specific humidity (line contours). Biases are shown for (c, d) UKESM1-historical, (e, f) GC3.1 N96-pi and (g, h) GC3.1 N216-pi. Only biases statistically significant to the 95% confidence level are shown, according to a Welch t-test between model and ERA5 data for all fields.



Figure S2. (a, b, c) OLR anomalies during active South Atlantic Convergence Zone (SACZ) events. (d, e) Frequency of active SACZ days and length of active SACZ events in reanalysis and model data, the standard deviation is shown as the error bar. The SACZ active days are constructed by first computing the first EOF of the monthly-mean deseasonalized OLR and then the daily OLR, previously filtered to remove periods higher than 99 days, is projected on the EOF pattern to produce a time-series of pseudo-principal components. Active SACZ days are found when this time-series of pseudo-PCs is greater than 1, and the persistence is measured as the number of continous days where the time-series is greater than 1.



Figure S3. DJF Longitude-height Walker circulation anomalies of specific humidity (colour-contours), ω (vectors) and zonal wind (linecontours) during El Niño events (left) and La Niña events (right). Results are shown for ERA-5 (upper), UKESM-pi (middle) and HadGEM3 piControl (lower).



Figure S4. SST anomalies [K] for East Pacific (EP) and Central Pacific El Niño events in HadSST, GC3 N216 and UKESM piControl. EP (CP) events were defined where the E-index (C-index) was greater than 1. In the bottom panel, the frequency of events per decade (with standard deviation as error bar) is shown for HadSST and the simulations used in this study. The E-index is computed from $(PC1-PC2)/\sqrt{2}$ and the C-index from $(PC1+PC2)/\sqrt{2}$.