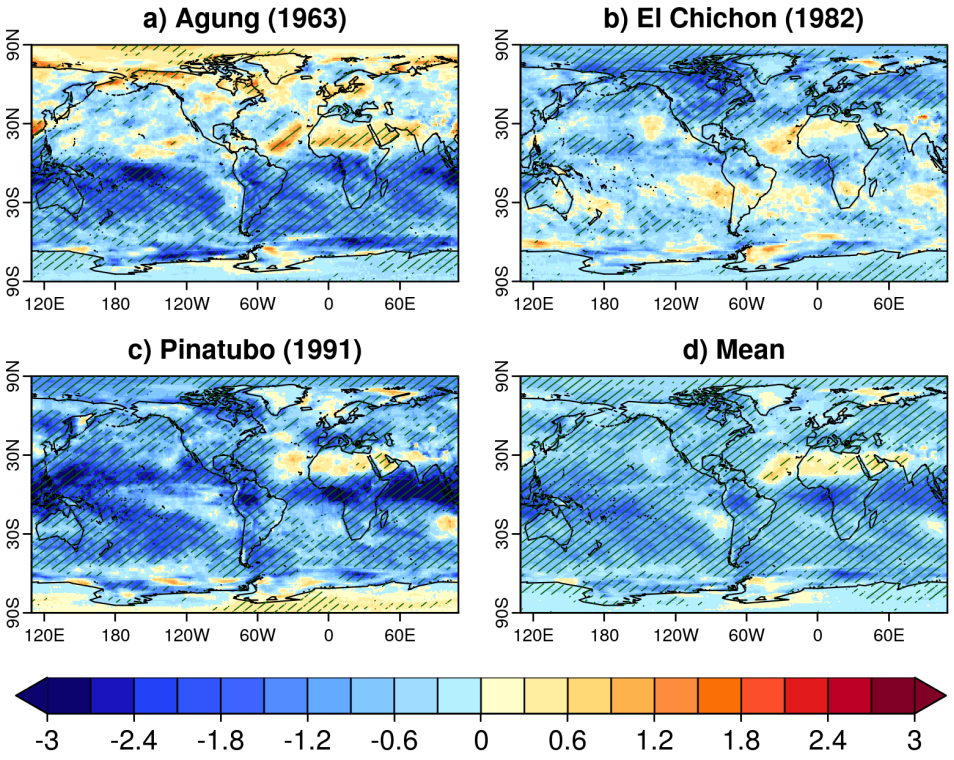

Figure S1. TOA (W/m^2) response (DCPP-A minus DCPP-C) the first year following the volcanic eruptions (June-May). Hatching indicates statistically significant anomalies and shading indicates model agreement.

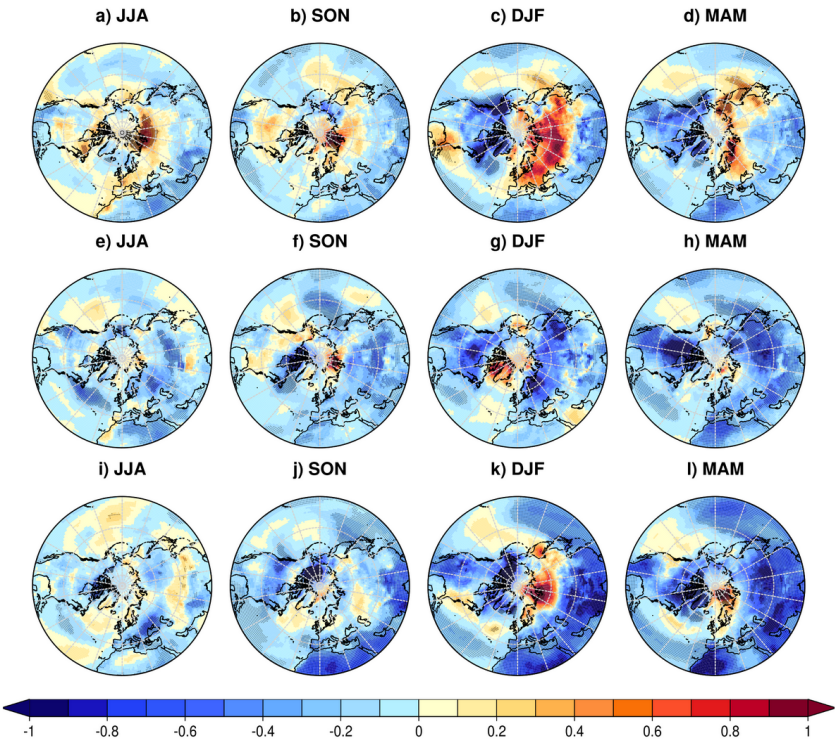

Figure S2. Surface temperature (°C) response (DCPP-A minus DCPP-C) for each season following the volcanic eruptions of Agung (a-d), El Chichon (e-h) and Pinatubo (i-l).

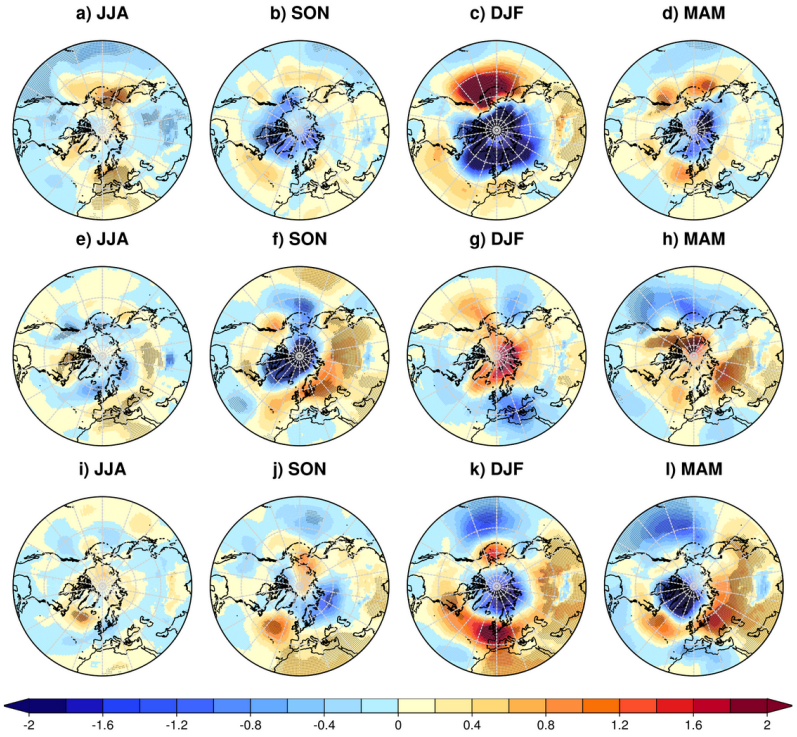

Figure S3. Sea level pressure (hPa) response (DCPP-A minus DCPP-C) for each season following the volcanic eruptions of Agung (a-d), El Chichón (e-h) and Pinatubo (i-l).

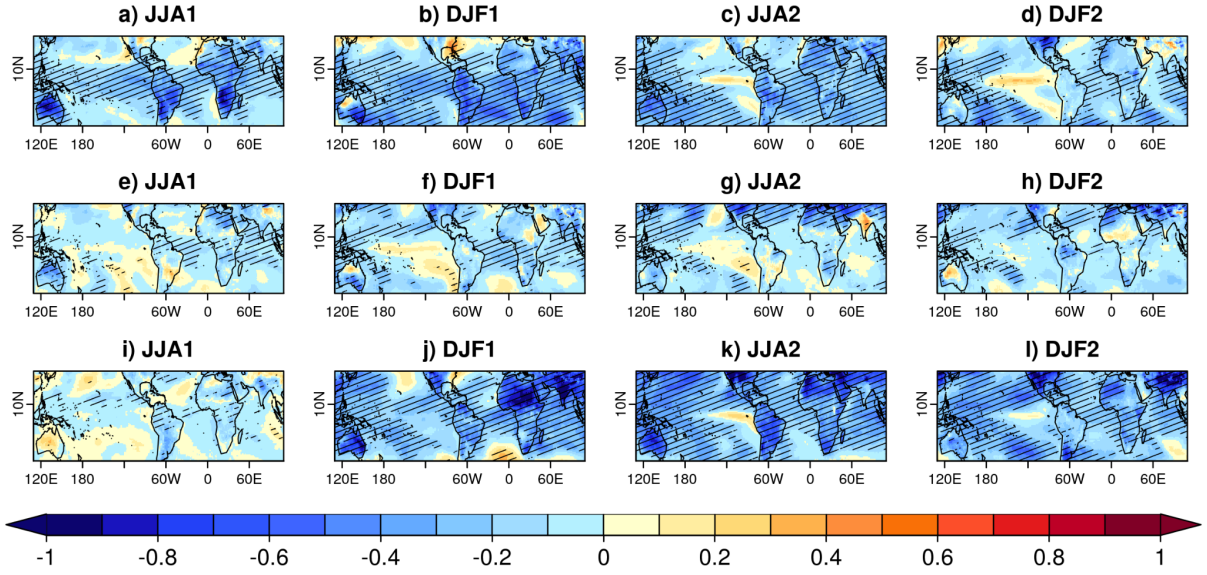

Figure S4. Model-mean surface air temperature responses (DCPP-A minus DCPP-C) following the eruptions in the first two years. The first row is for the eruption of Agung, the second row is for the eruption of El Chichon and the third row is for Pinatubo. Hatching indicates statistically significant anomalies.

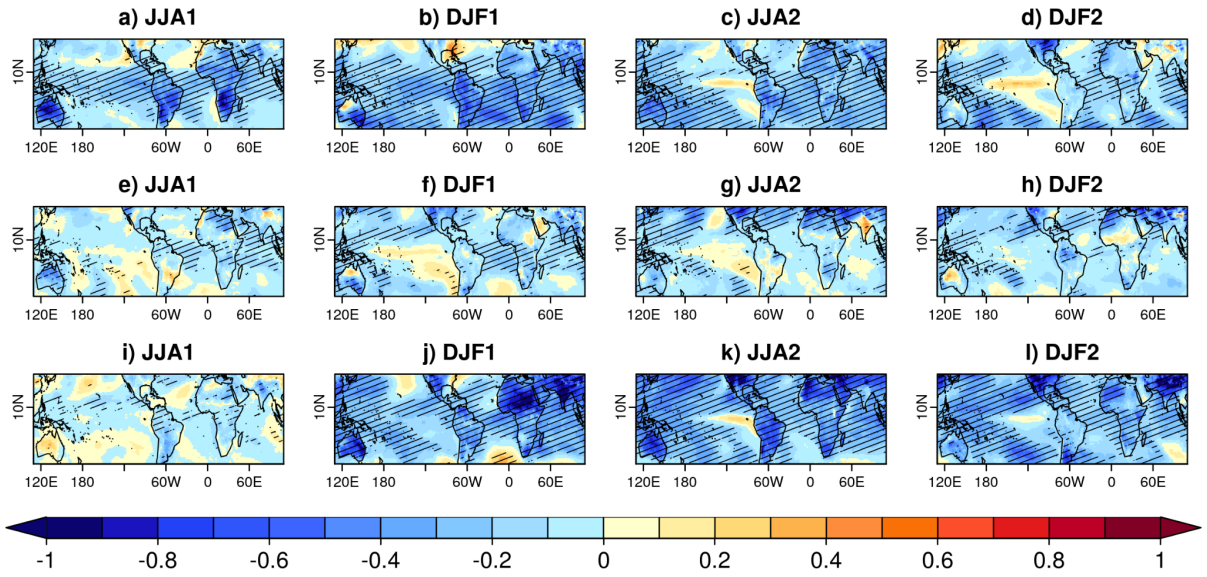

Figure S5. Model-mean precipitation responses (DCPP-A minus DCPP-C) following the eruptions in the first two years. The first row is for the eruption of Agung, the second row is for the eruption of El Chichon and the third row is for Pinatubo. Hatching indicates statistically significant anomalies.

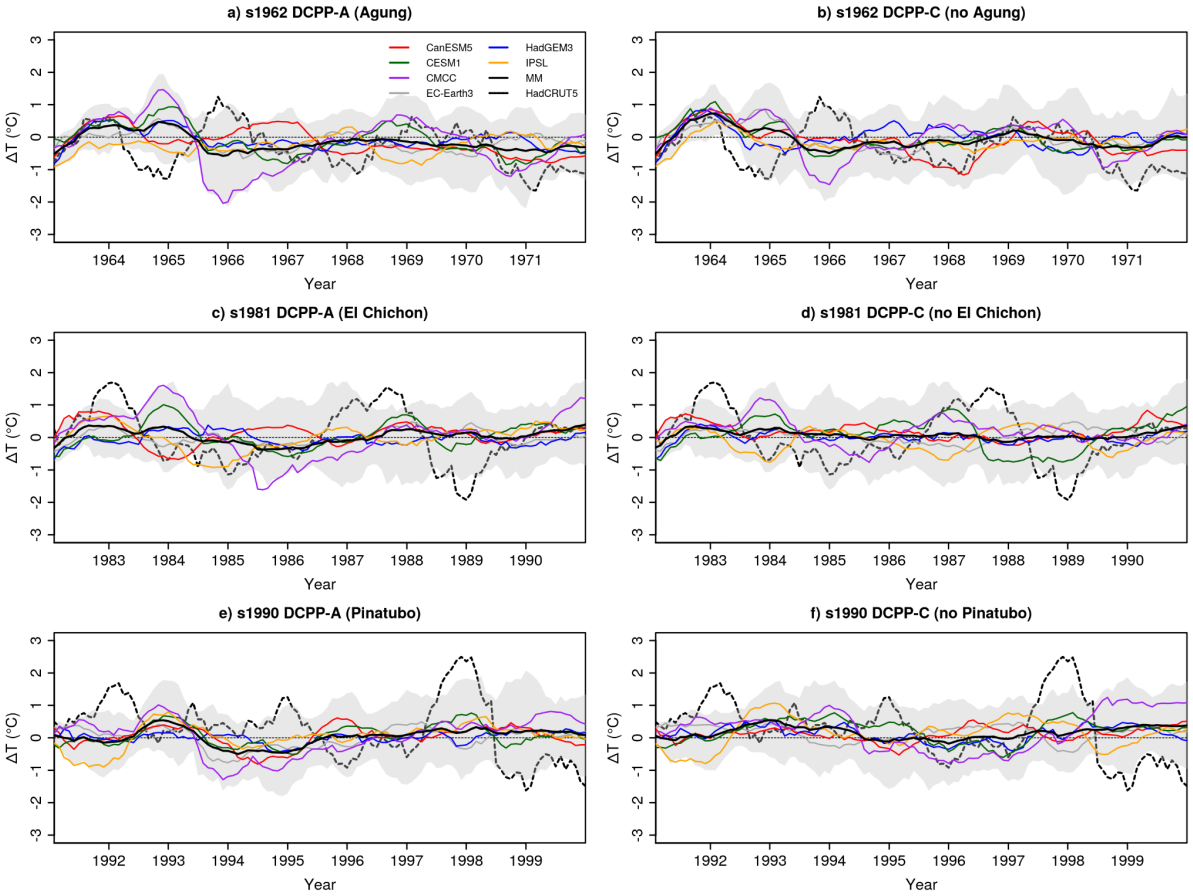

Figure S6. Niño 3.4 forecast anomalies in the predictions initialised in 1962, 1981 and 1990 for the DCPP-A (with volcanic forcing) and DCPP-C (without volcanic forcing) experiments. HadCRUT5 is used as the observational reference (dashed

line). The anomalies have been computed with respect to the period 1970-2005 (see methods for further information). The shading is the multi-model member spread calculated as the 10th and 90th percentiles of the entire ensemble.

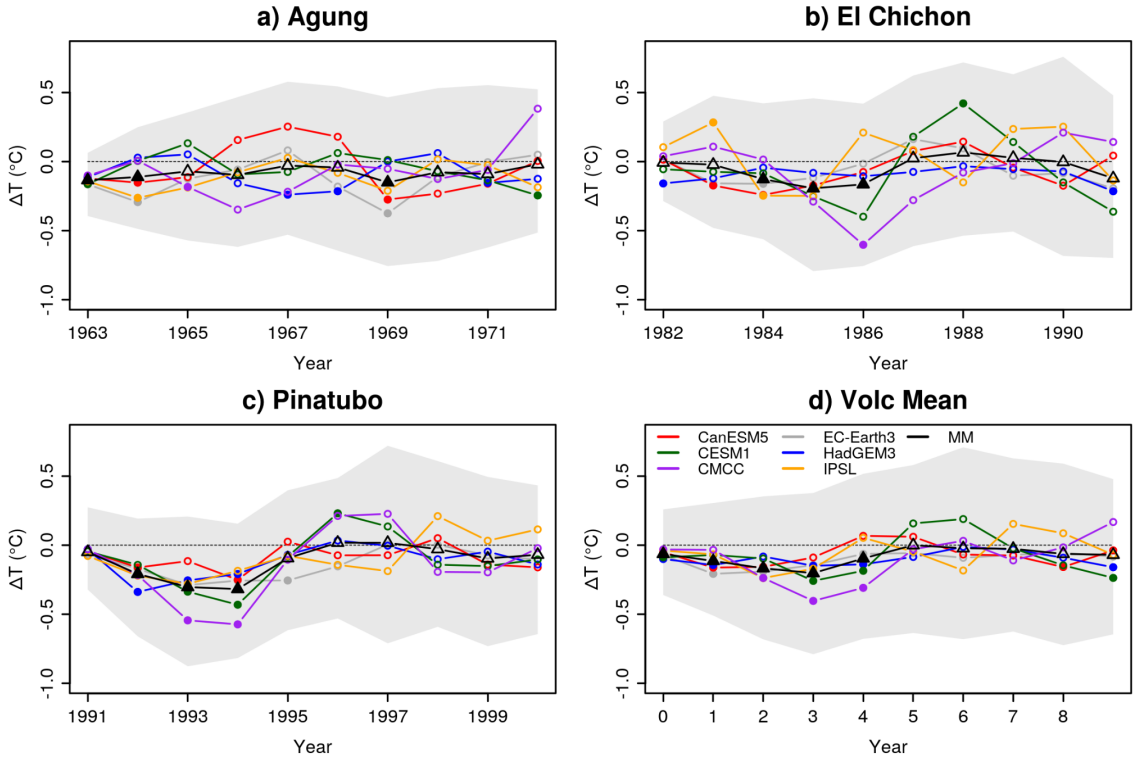

Figure S7. Annual mean tropical Pacific sea surface temperature (20°S–20°N, 160°E–80°W) response (°C) to the volcanic eruptions. Filled circles/triangles indicate statistically significant differences (see methods). The shading is the multi-model member spread calculated as the 10th and 90th percentiles.

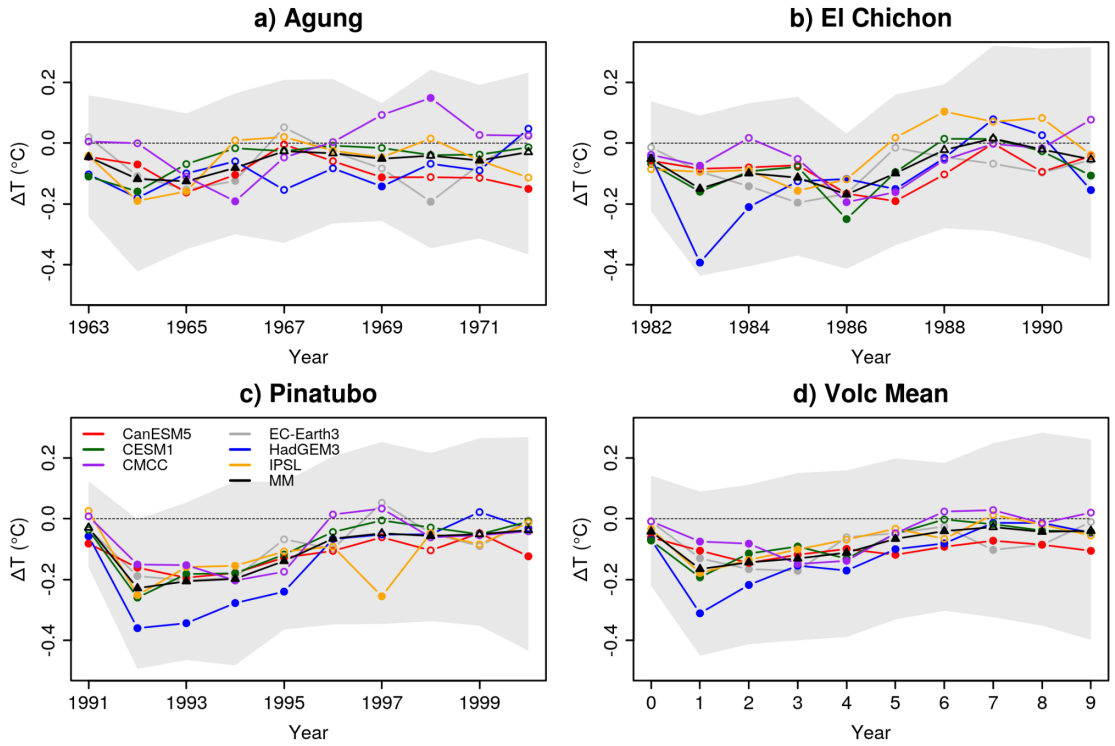

Figure S8. Annual mean North Atlantic (0ºN-60ºN, 80ºW-0º) sea surface temperature response (DCPP-A minus DCPP-C) to the volcanic eruptions. Filled circles/triangles indicate statistically significant differences (see methods). The shading is the multi-model member spread calculated as the 10th and 90th percentiles.

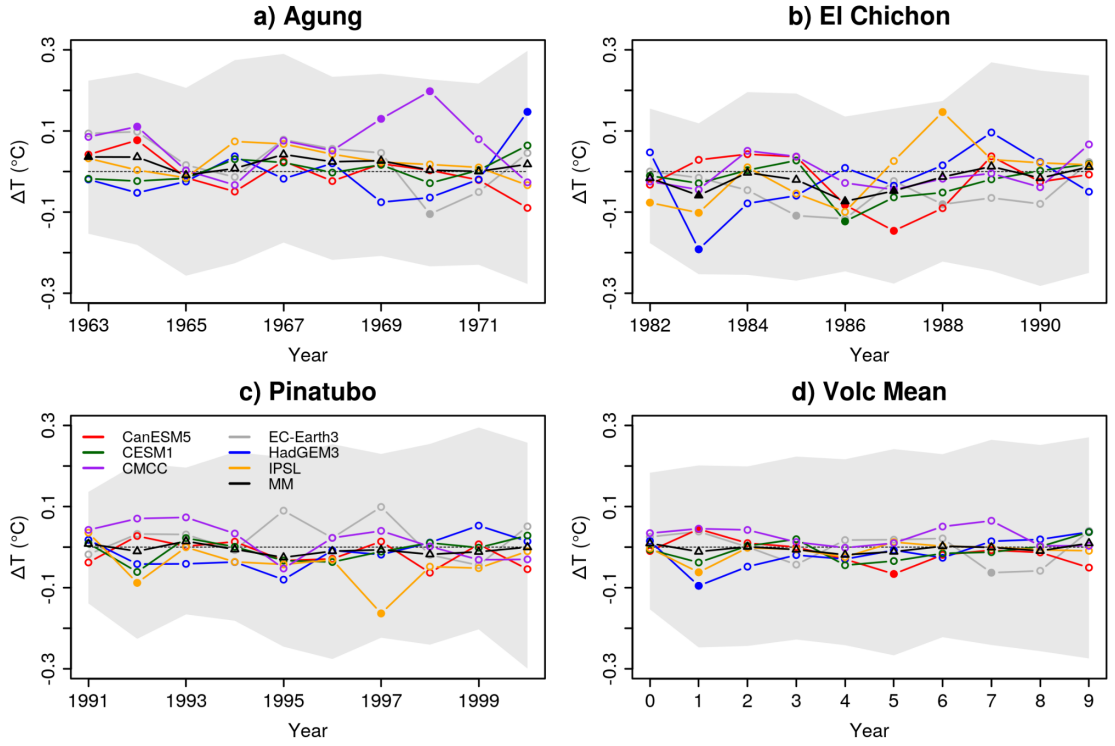

Figure S9. AMV response (DCPP-A minus DCPP-C) to the volcanic eruptions. Filled circles/triangles indicate statistically significant differences (see methods). The shading is the multi-model member spread calculated as the 10th and 90th percentiles.

Tables:

Models	*Agung*		*El Chichon*		*Pinatubo*	
	DCPP-A (Volc)	*DCPP-C (No Volc)*	*DCPP-A (Volc)*	*DCPP-C (No Volc)*	*DCPP-A (Volc)*	*DCPP-C (No Volc)*
EC-Earth3	**0.17**	0.26	0.16	**0.14**	**0.17**	0.19
CanESM5	**0.15**	0.18	**0.12**	0.17	**0.17**	0.22
HadGEM3-GC31-MM	**0.18**	0.25	0.17	**0.13**	**0.17**	0.20
CESM1-1-CAM5-CMIP5	**0.15**	0.21	**0.14**	0.18	**0.14**	0.21
IPSL-CM6A-LR	**0.16**	0.18	**0.13**	0.14	**0.17**	0.21
CMCC-CM2-SR5	**0.16**	0.17	**0.15**	0.20	**0.20**	0.22
Multi-Model	**0.14**	0.20	**0.13**	0.14	**0.16**	0.20

Table S1. Root mean square error of the monthly mean global surface temperature (ºC) anomalies for years 1-9. Smaller values are in bold. The anomalies are computed with respect to the period 1970-2005 (see methods). HadCRUT5 is used as the observational reference.

Forecast Range	*s1962*		*s1981*		*s1990*	
	DCPP-A (Agung)	*DCPP-C (no Agung)*	*DCPP-A (El Chichon)*	*DCPP-C (no El Chichon)*	*DCPP-A (Pinatubo)*	*DCPP-C (no Pinatubo)*
Yr1	0.44	**0.43**	**0.53**	0.54	0.46	**0.45**
Yrs 2-5	**0.29**	0.33	**0.22**	0.25	**0.25**	0.30
Yrs 6-9	**0.30**	0.32	0.19	0.19	**0.29**	0.33

Table S2. RMSE for the surface temperature anomaly patterns in the three DCPP-A and DCPP-C multi-model mean hindcasts (initialised in 1962, 1981 and 1990) against the HadCRUT5 observational dataset. Smaller values are in bold. The anomalies are computed with respect to the period 1970-2005 (see methods).

Models	*Agung*		*El Chichon*		*Pinatubo*	
	DCPP-A (Volc)	*DCPP-C (No Volc)*	*DCPP-A (Volc)*	*DCPP-C (No Volc)*	*DCPP-A (Volc)*	*DCPP-C (No Volc)*
EC-Earth3	0.29	0.29	**0.19**	0.21	0.29	**0.22**
CanESM5	**0.17**	0.21	**0.14**	0.18	0.28	**0.27**
HadGEM3-GC31-MM	**0.2**1	0.27	0.21	**0.14**	0.28	**0.22**
CESM1-1-CAM5-CMIP5	0.25	0.25	**0.20**	0.23	0.22	**0.21**
IPSL-CM6A-LR	0.30	**0.25**	**0.20**	0.22	0.31	**0.25**
CMCC-CM2-SR5	0.33	**0.26**	0.28	**0.17**	0.37	**0.36**
Multi-Model	**0.22**	0.23	0.15	**0.14**	0.28	**0.23**

Table S3. Root mean square error of the annual mean tropical Pacific Ocean (20°S–20°N, 160°E–80°W) sea surface temperature (ºC) forecast anomalies for years 1-9. Smaller values are in bold. The anomalies are computed with respect to the period 1970-2005 (see methods). HadSST.4.0.1.0 is used as the observational reference.

Models	*Agung*		*El Chichon*		*Pinatubo*	
	DCPP-A (Volc)	*DCPP-C (No Volc)*	*DCPP-A (Volc)*	*DCPP-C (No Volc)*	*DCPP-A (Volc)*	*DCPP-C (No Volc)*
EC-Earth3	**0.13**	0.21	**0.17**	0.18	**0.09**	0.20
CanESM5	**0.15**	0.20	**0.21**	0.25	**0.10**	0.20
HadGEM3-GC31-MM	**0.16**	0.21	**0.21**	0.19	**0.10**	0.22
CESM1-1-CAM5-CMIP5	**0.16**	0.24	**0.16**	0.17	**0.11**	0.26
IPSL-CM6A-LR	**0.10**	0.19	**0.16**	0.21	**0.12**	0.23
CMCC-CM2-SR5	0.18	**0.15**	**0.18**	0.20	**0.10**	0.17
Multi-Model	**0.12**	0.18	**0.17**	0.19	**0.09**	0.21

Table S4. Root mean square error of the monthly mean North Atlantic Ocean (20°S–20°N, 160°E–80°W) sea surface temperature (ºC) forecast anomalies for years 1-4. Smaller values are in bold. The anomalies are computed with respect to the period 1970-2005 (see methods). HadSST.4.0.1.0 is used as the observational reference.