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Supplement of

Seasonal aridity in the Indo-Pacific Warm Pool during the Late Glacial driven by El Niño-like conditions

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SUPPLEMENTARY INFORMATION

Supplementary Table 1. Proxy data compilation for the IPWP region used in Fig. 1.

Reference	**Type**	**Proxy**	**Site name**	**N (°)**	**E (°)**
Dubois 2014	Marine core	$\delta^{13}C$	East Borneo	2.9	118.4
			Flores	-9.6	120.9
Partin 2007	Cave speleothem	$\delta^{18}O$	Gunung Buda	4.2	114.9
Chabangborn 2018	Marine core	Pollen	Core 17962	7.2	112.1
Ayliffe 2013	Cave speleothem	$\delta^{18}O$	Liang luar	-8.5	120.4
Denniston 2017	Terrestrial deposit	$\delta^{13}C$	KNI, BGC	-15.3	128.6
Dykoski 2005	Cave speleothem	$\delta^{18}O$	Dongge	25.3	108.1
Haberle 2005	Terrestrial deposit	Pollen	Lake Euramoo	-17.2	145.6
Van der Kaars 2000	Marine core	Pollen	Core SHI-9014	-5.5	126.6
Haberle 1998	Terrestrial deposit	Pollen	Tari basin	-5.8	143.0
Kealhofer 1998	Terrestrial deposit	Pollen	3KUM	17.1	103.0
Wang 2007	Marine core	Pollen	Core 18287	5.7	110.7
Yang 2020	Marine core	Pollen	CG-2	6.4	110.2
Fraser 2014	Marine core	$\delta^{18}O$ benthic, XRF, Uk^{37}	Core MD06-3075	6.5	125.8
Hapsari 2017	Terrestrial deposit	Pollen and $\delta^{13}C$	Sungai Buluh	-1.2	103.6
Schröder 2018	Marine core	$\delta^{18}O$ benthic	22	1.4	119.1
			26	-3.6	118.2
			15	-3.6	119.4
			40	-6.9	119.6
Konecky 2016	Terrestrial deposit	$\delta^{13}C$, δD leaf wax	Tuwoti	-2.9	121.5
Niedemeier 2014	Marine core	$\delta^{13}C$, δD leaf wax	Nias	1.2	98.1
Wurster 2010	Cave guano	$\delta^{13}C$	Batu	3.2	101.7
			Palawan S	8.5	117.6
			Palawan N	10.5	119.5
Wurtzel 2018	Cave speleothem	$\delta^{18}O$	Tangga Cave	-0.35	100.75

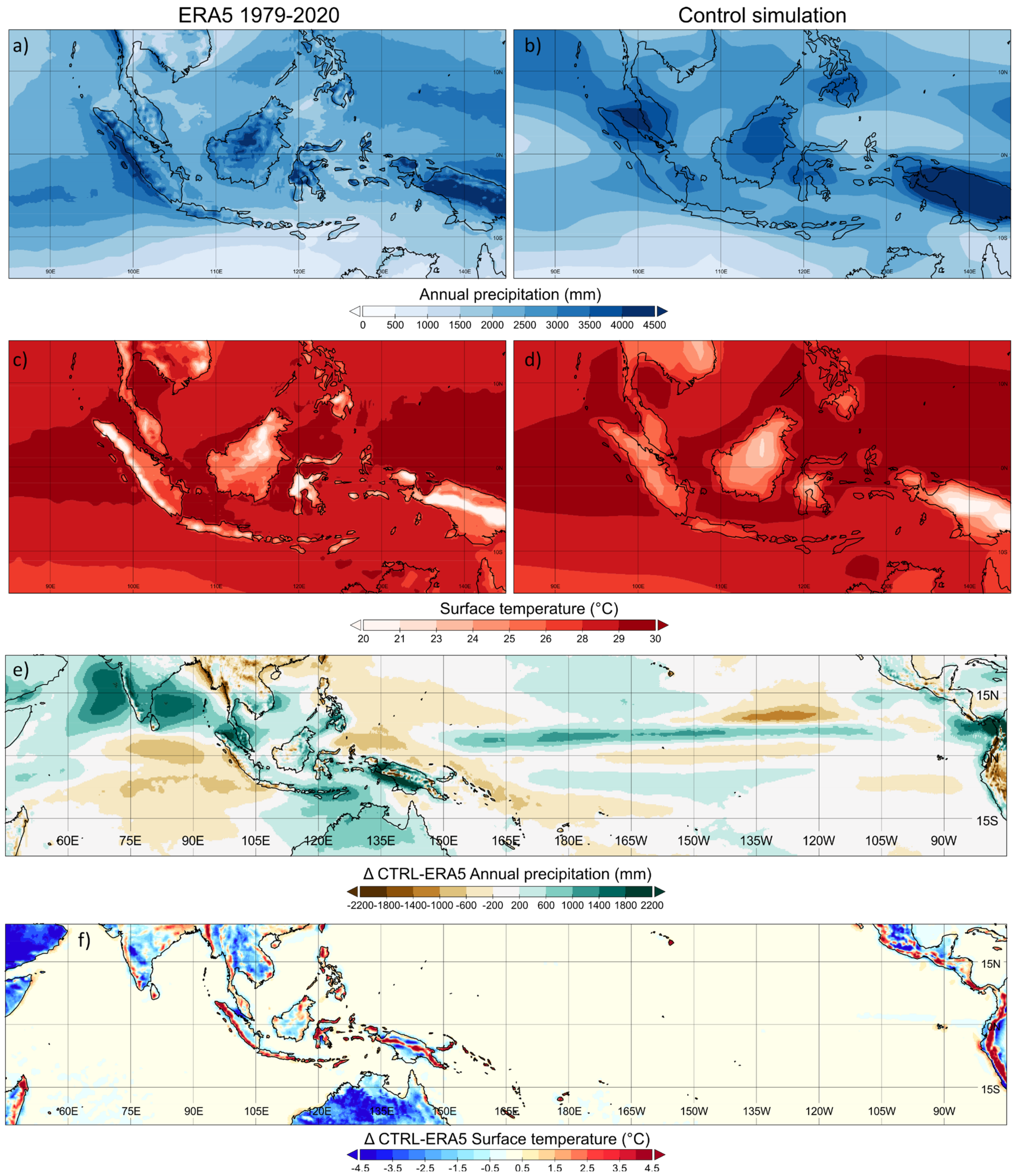


Figure S1. CESM1 model validation of the modern climate (year 2000) compared to ERA5 reanalysis of 1979-2020. a and b) precipitation, c and d) temperature, e) precipitation bias and f) temperature bias. Note that temperature bias in the oceans is near 0 °C since the CESM1 simulation uses a prescribed ocean state based on observations.

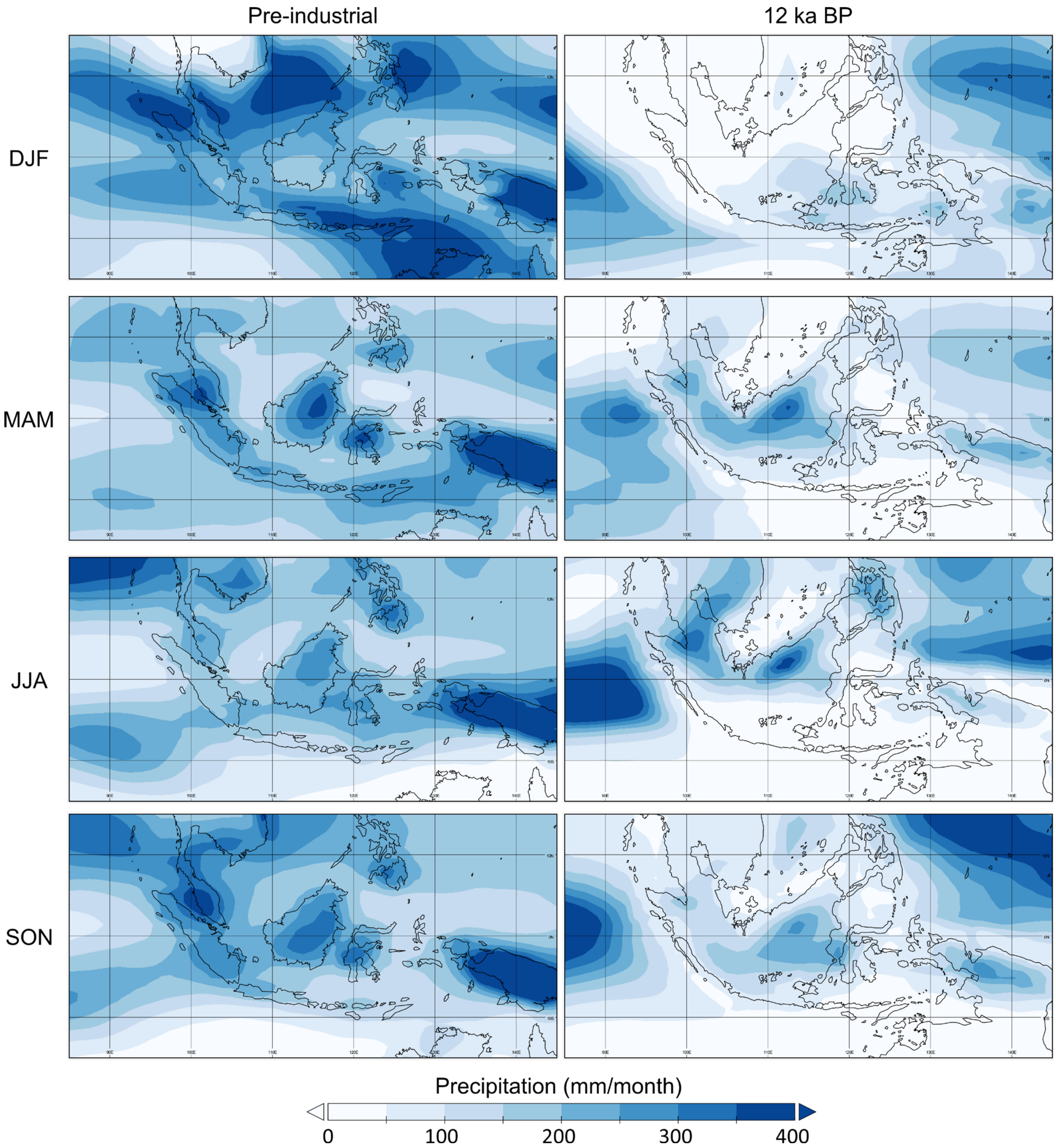


Figure S2. Simulated seasonal monthly mean precipitation (mm/month) for PI and 12 ka BP with CESM1. Coastlines at 12 ka BP are adjusted to the lower sea-level of around 55 m where roughly 70% of the Sunda Shelf were still exposed.

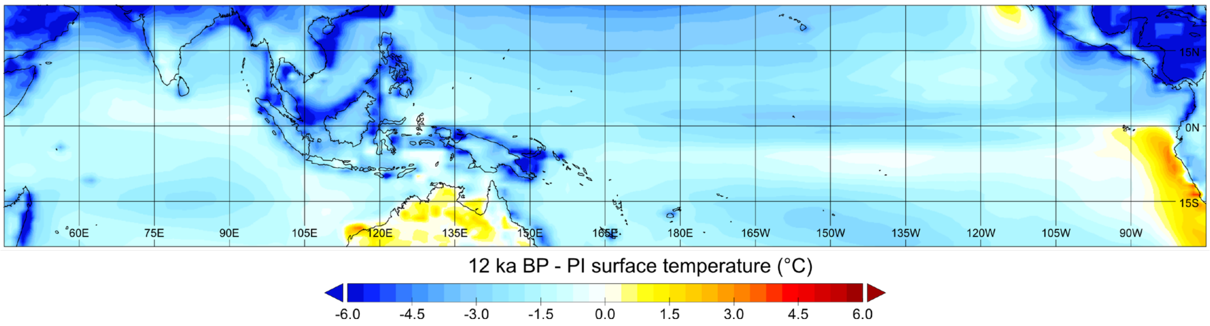
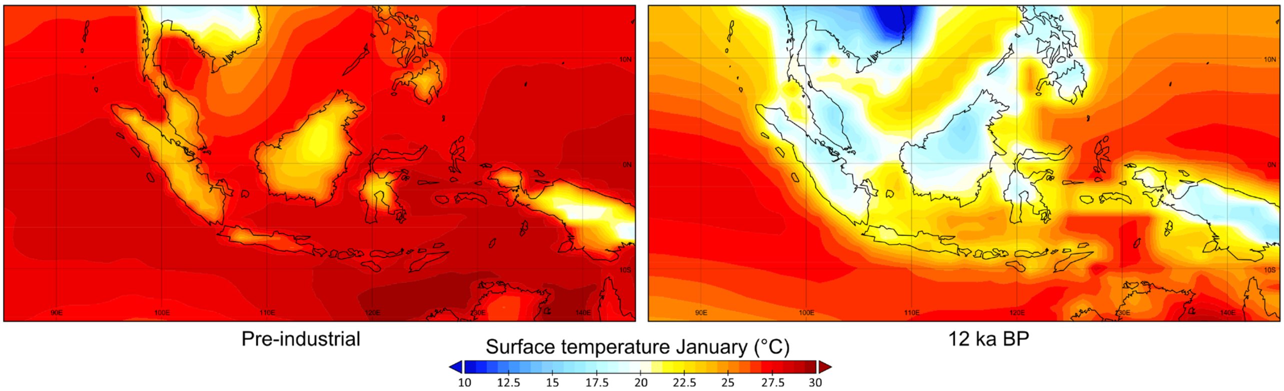
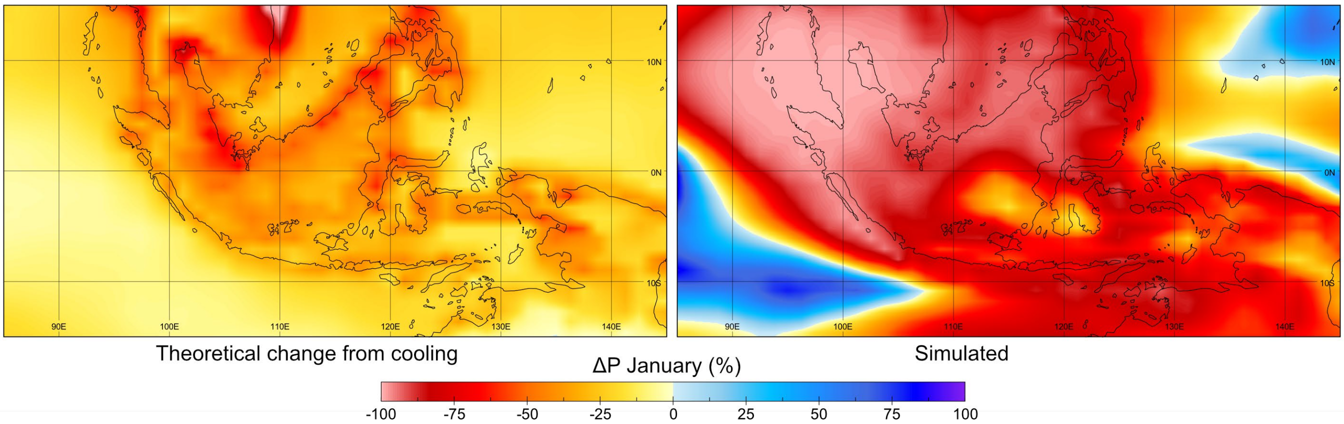


Figure S3. Annual mean surface temperature difference between 12 ka BP and PI simulated by CESM1. Red color scale indicates warmer temperatures at 12 ka BP compared to PI, blue color scale indicates cooling. The strong cooling along coastlines are partly the result of comparing land areas of 12 ka BP with ocean areas at PI due to higher sea-levels.


Pre-industrial

12 ka BP

Figure S4. Mean January surface temperatures at PI and 12 ka BP simulated by CESM1. Coastlines at 12 ka BP represent the 55 m lower sea-level compared to PI. Major changes at 12 ka BP refer to much colder land areas for ISEA and the absence of today's IPWP (>28°C) region with a generally several degrees colder SST. The much stronger cooling over land than ocean at 12 ka BP promotes a reversal of the land-sea circulation with subsidence over ISEA and a breakdown of deep convection.


Theoretical change from cooling

Simulated

Figure S5. Comparison of theoretically expected relative precipitation change assuming a 7 % decrease in P per degree cooling of $\Delta TS_{12ka-PI}$ (left) with the actually simulated total change in precipitation at 12 ka BP relative to PI (right). The example for the overall driest month at 12 ka BP (January) highlights that the reason for seasonal aridity stems mainly from dynamical rather than only thermodynamical changes.

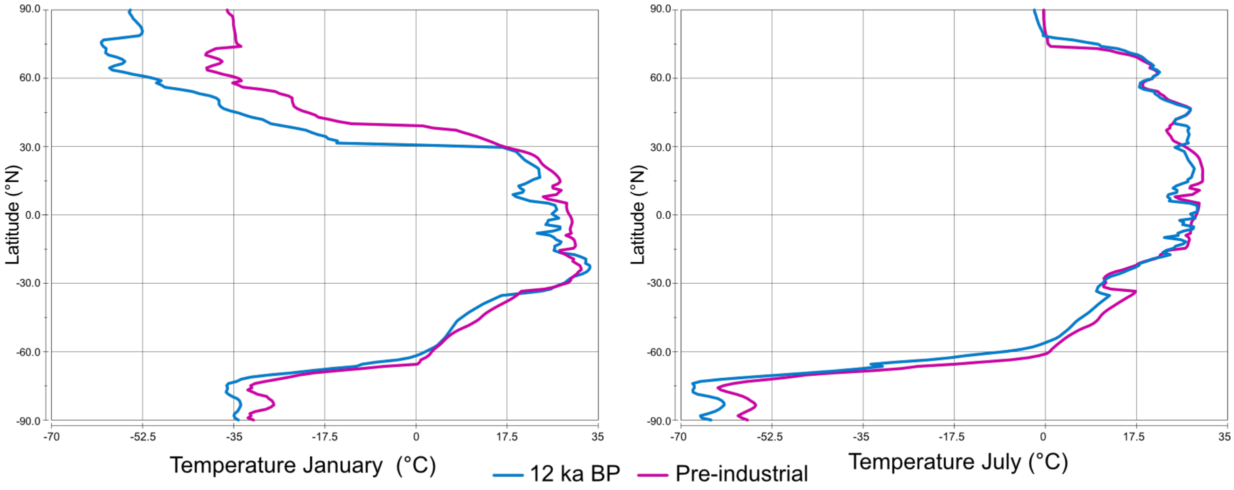


Figure S6. Comparison of zonally averaged surface temperatures for January and July along the 125 °E longitude (over Australia, Siberia and east ISEA) as simulated by CESM1 for 12 ka BP and PI. Note the large cooling north of 30°N in January for 12 ka BP which strongly increased the thermal gradient relative to the tropics.

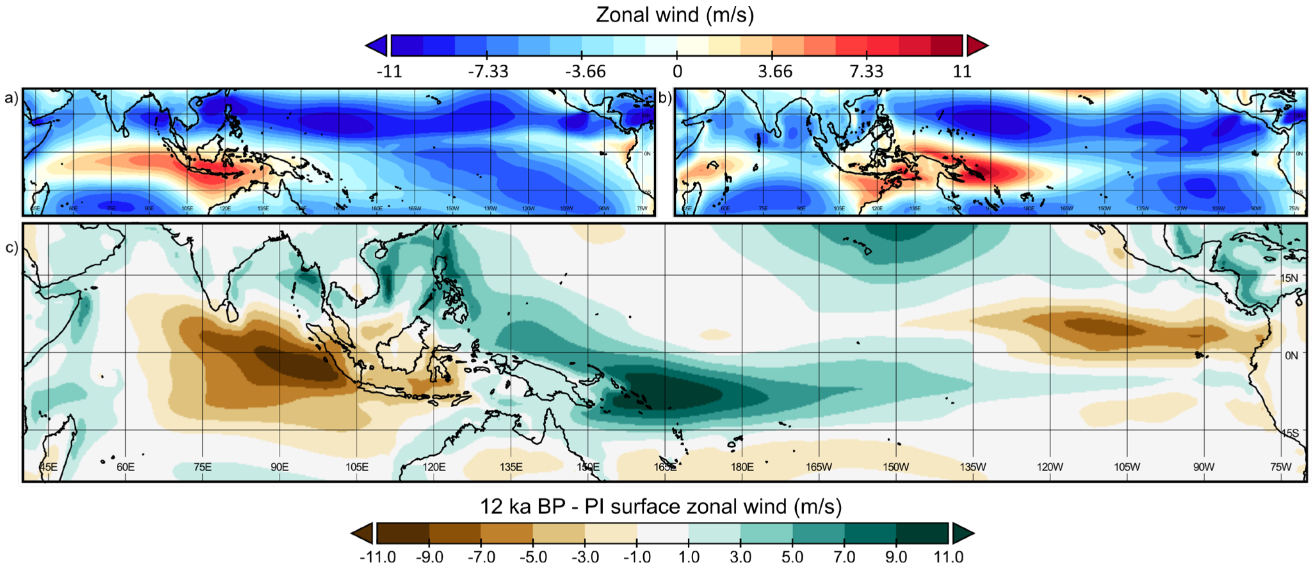


Figure S7: Comparison of zonal winds simulated by CESM1 in January for a) pre-industrial and b) 12 ka BP and c) the resulting difference in the wind vectors. Positive (red) indicate predominantly westerly winds and negative (blue) indicate easterly winds. Differences in c) between the periods with negative (brown) indicating slowdown of westerly winds, or even reversal to easterly zonal winds, and positive (green) indicate the opposite. The dipole in c) represents the reversal of the land-sea circulation to a divergent flow regime over ISEA consistent with strong terrestrial cooling of ISEA relative to the ocean in Fig. S3.

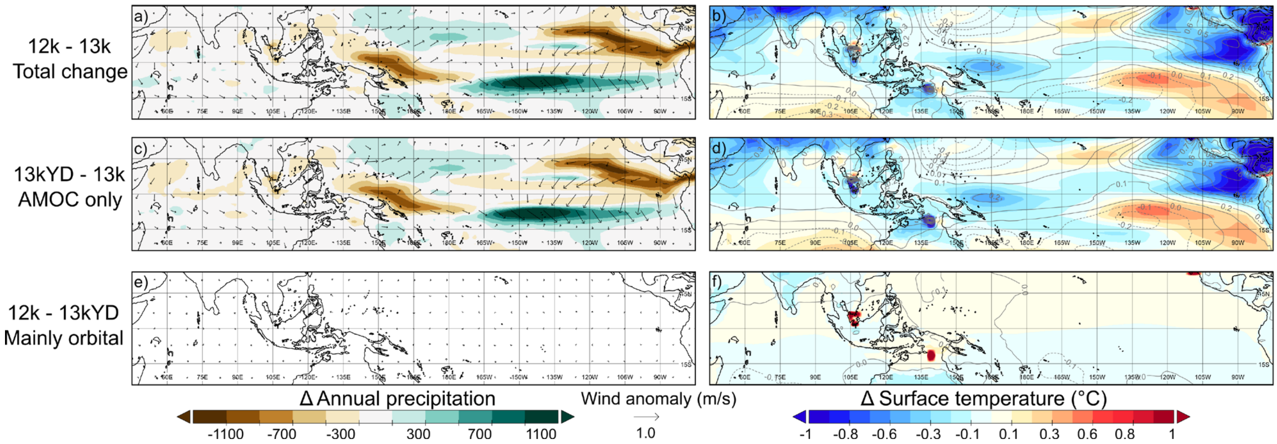


Figure S8. Indo-Pacific changes in precipitation and temperature between 12 and 13 ka BP and the 13kYD hosing experiment. a and b) Difference between 12-13 ka BP simulations, representing the total combined effect of changes in all forcings between the periods. c and d) 13kYD-13 ka BP, representing changes in freshwater forced reduction in AMOC only. e and f) show the difference between 12 ka BP simulation and 13kYD experiment, and represents the residual changes driven by orbital and greenhouse gas forcings and ice sheet and sea level from 13 ka BP but using the same (Younger Dryas) ocean state. Also shown are the anomalies in surface winds as vectors in a, c and e and tropical (±23.5°N) sea level pressure difference as isobars in b, d and f where dotted isobars denote negative values and solid isobars denote positive values.

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