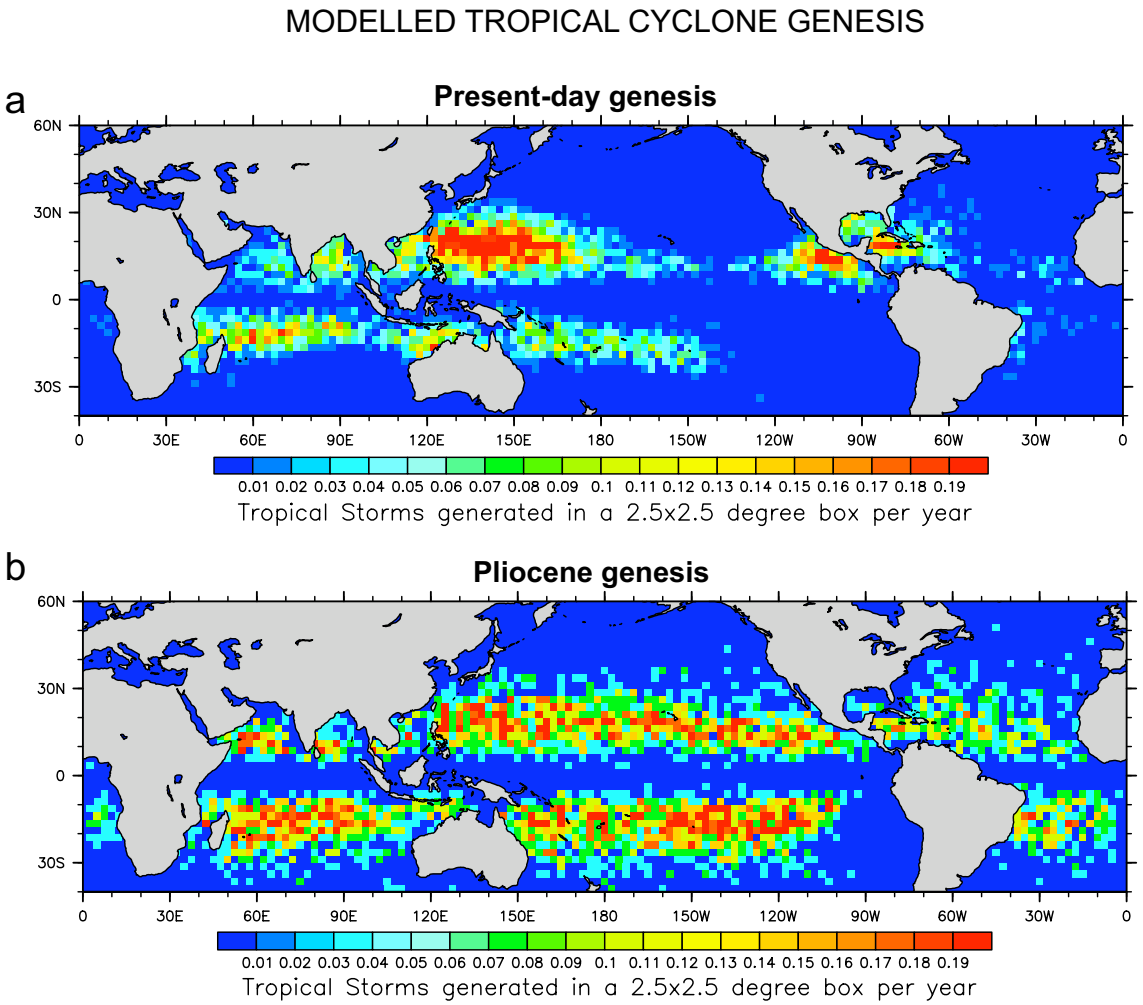
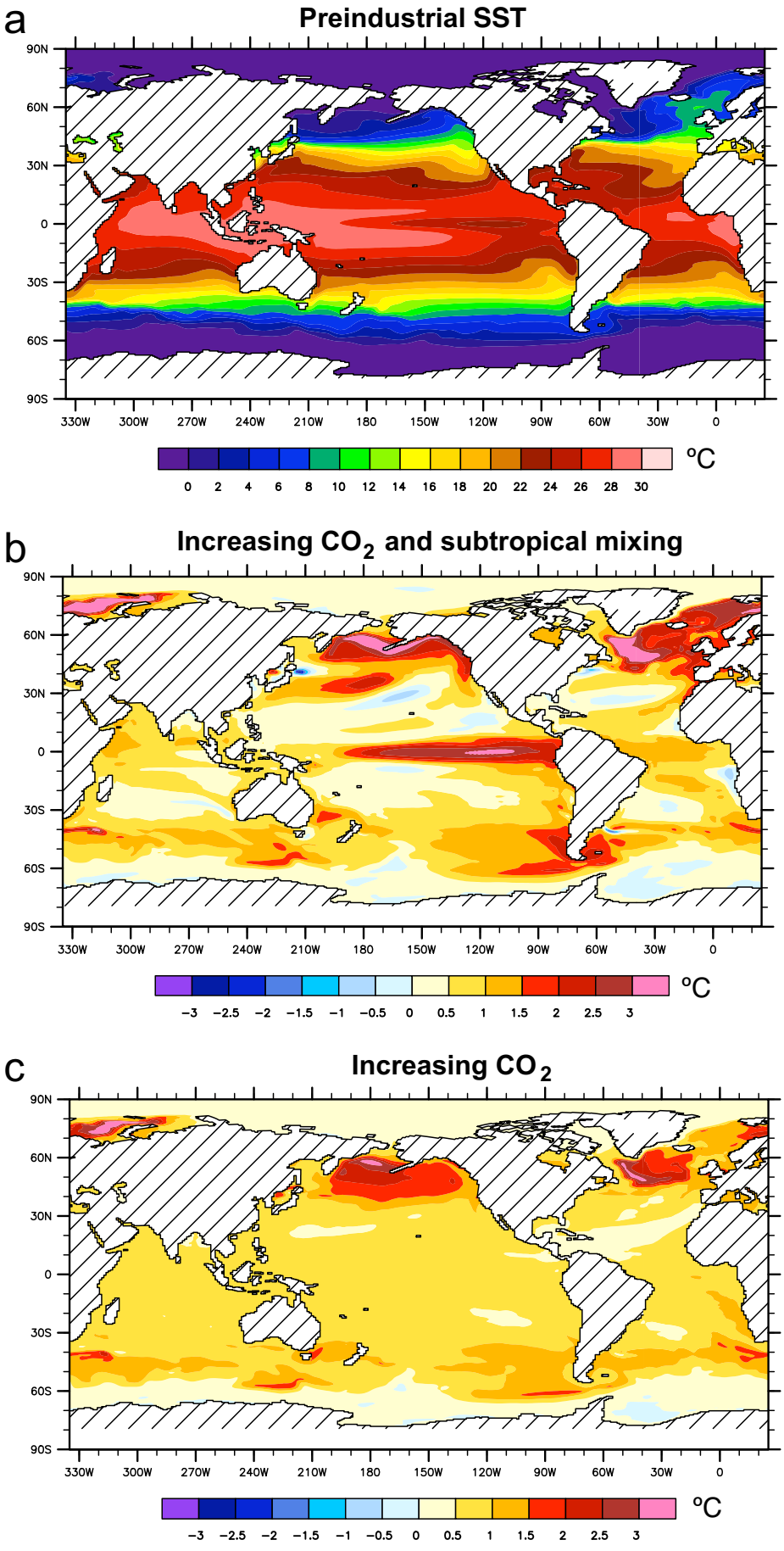
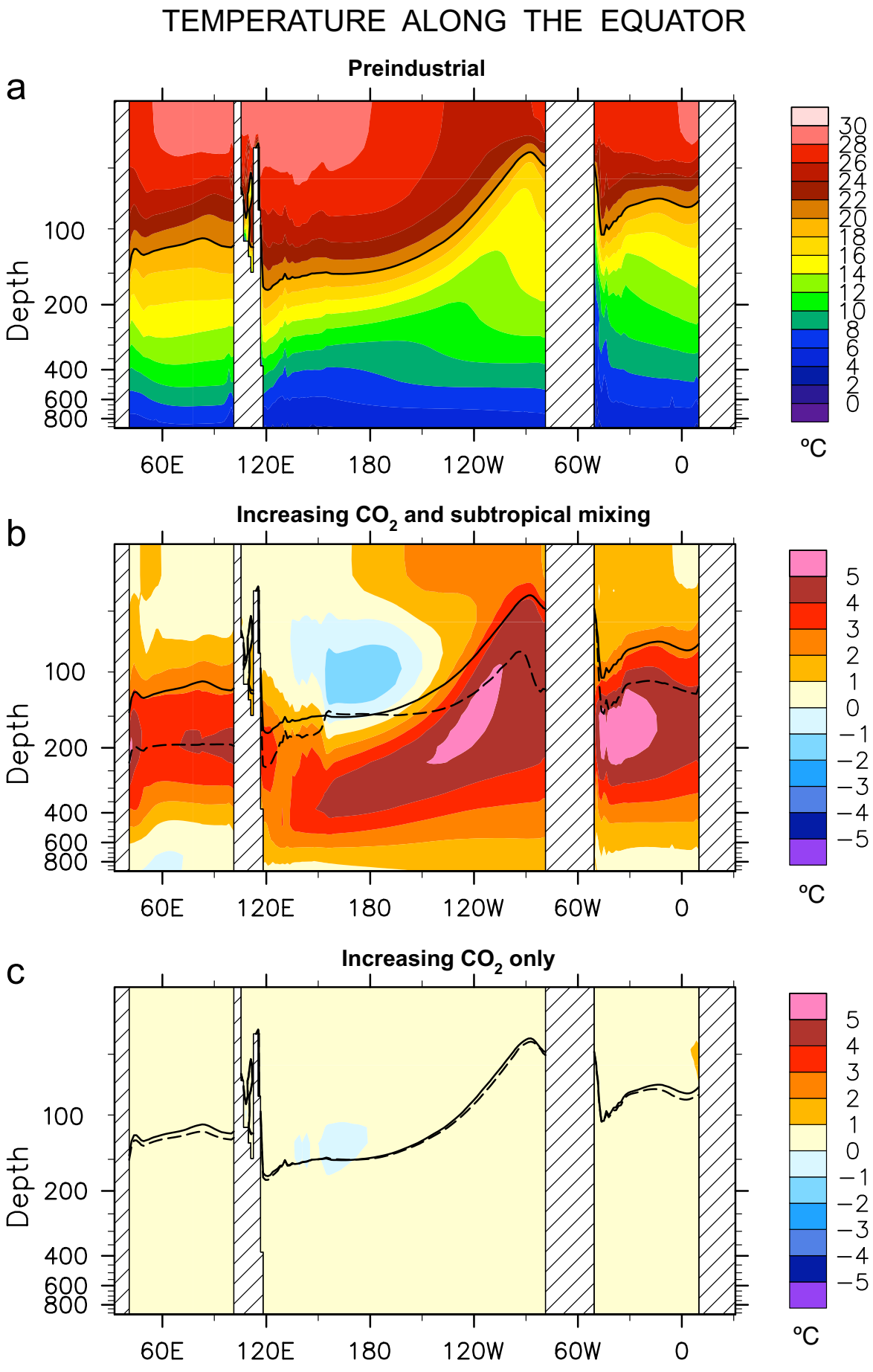


Supplementary Figure 1 | Modelled genesis of tropical cyclones: (a) The present-day climate. (b) The early Pliocene. The panels show the average number of tropical cyclones originating annually in each 2.5^{o} x 2.5^{o} box in the Statistical DownScaling Model. The average number of tropical cyclones passing through each box is at least an order of magnitude larger. Note the expansion of the tropical cyclone activity and the overall increase in the number of cyclones during the Pliocene.

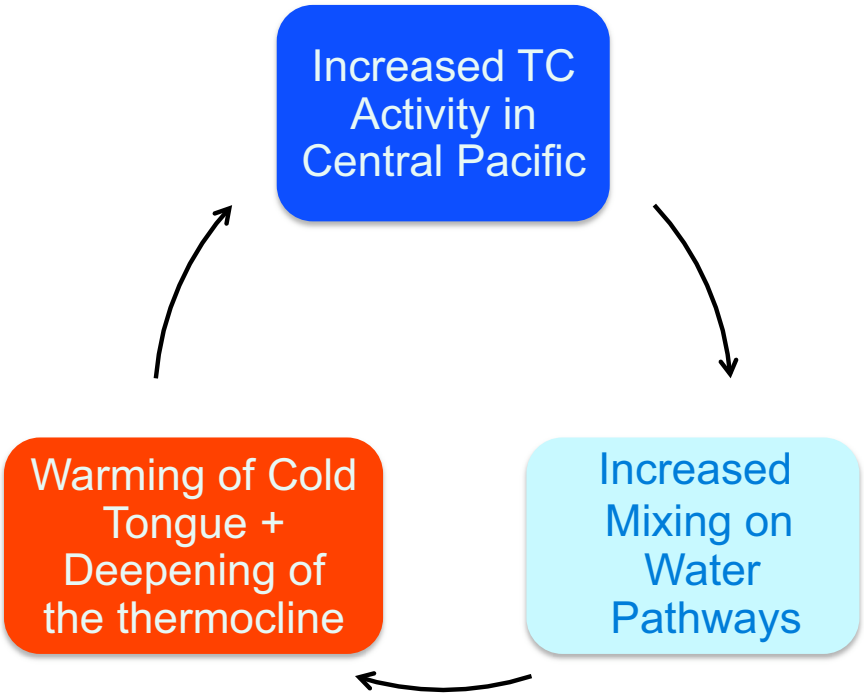

a
Preindustrial SST
90N
60N
30N
0
30S
60S
90S
330W 300W 270W 240W 210W 180 150W 120W 90W 60W 30W 0
°C
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
b
Increasing CO_2 and subtropical mixing
90N
60N
30N
0
30S
60S
90S
330W 300W 270W 240W 210W 180 150W 120W 90W 60W 30W 0
°C
−3 −2.5 −2 −1.5 −1 −0.5 0 0.5 1 1.5 2 2.5 3
c
Increasing CO_2
90N
60N
30N
0
30S
60S
90S
330W 300W 270W 240W 210W 180 150W 120W 90W 60W 30W 0
°C
−3 −2.5 −2 −1.5 −1 −0.5 0 0.5 1 1.5 2 2.5 3

Supplementary Figure 2 | Global SST changes simulated in the coupled experiments. (a) Preindustrial climate conditions. (b) SST change in response to increasing atmospheric CO_2 concentration from 285ppm (preindustrial) to 355ppm (the level of 1990) and enhancing vertical diffusivity in the upper ocean in the extra-tropical bands after 200 years of calculations for the Pliocene scenario. The SST increase has a signature of permanent El Niño-like conditions with the maximum warming reaching 3.5^{o}C in the eastern equatorial Pacific. (c) SST changes in response to increasing CO_2 concentration alone. Note the warming of the Northern Pacific and Atlantic. This warming is stronger in the experiment with enhanced ocean mixing when it can reach ~5^{o}C. A moderate cooling off South-West Africa in (b) is caused by prescribing too strong diffusivity near the coast, which is not supported by the PDI distribution in Fig. 3.


TEMPERATURE ALONG THE EQUATOR
a
Preindustrial
Depth
100
200
400
600
800
60E
120E
180
120W
60W
0
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
°C
b
Increasing CO2 and subtropical mixing
Depth
100
200
400
600
800
60E
120E
180
120W
60W
0
5
4
3
2
1
0
−1
−2
−3
−4
−5
°C
c
Increasing CO2 only
Depth
100
200
400
600
800
60E
120E
180
120W
60W
0
5
4
3
2
1
0
−1
−2
−3
−4
−5
°C

Supplementary Figure 3 | Ocean thermal structure along the equator in the coupled simulations (averaged between 5°S-5°N). (a) Ocean temperature for preindustrial climate conditions. (b) Temperature changes in response to increasing atmospheric CO_2 concentration from 285ppm (preindustrial) to 355ppm (the level of 1990) and enhancing vertical diffusivity in the upper ocean in the extra-tropical bands after 200 years of calculations for the Pliocene scenario. (c) Temperature changes in response to increasing CO_2 concentration alone. The solid black lines in all panels show the depth of the 20°C isotherm, a proxy for the thermocline depth, in the preindustrial simulation. The dashed lines show the 20°C isotherm in the perturbed experiments. Note the deepening of the thermocline in all three oceans caused by the enhanced extra-tropical mixing, as well as the reduction of the thermocline slope in the Pacific related to the Bjerknes feedback. Also note the strong warming (up to 6°C) below the thermocline, especially in the Pacific and Atlantic oceans, and a moderate subsurface cooling (1-2°C) in the western Pacific.

Ocean Circulation - Tropical Cyclone Feedback



Supplementary Figure 4 | Schematic of the positive climate feedback based on interaction between ocean circulation and tropical cyclones.