Extended Data Information

The Thermal and Mechanical Effects of the Tibetan Plateau on Asian Monsoons

Hyein Jeong[1,2], Hyo-Seok Park[1,2]* and Kyong-Hwan Seo[3,4]

[1]Institute of Ocean and Atmospheric Science (IOAS), Hanyang University, Ansan, South Korea

[2]Department of Marine Science and Convergence Engineering, Hanyang University, Ansan, South Korea
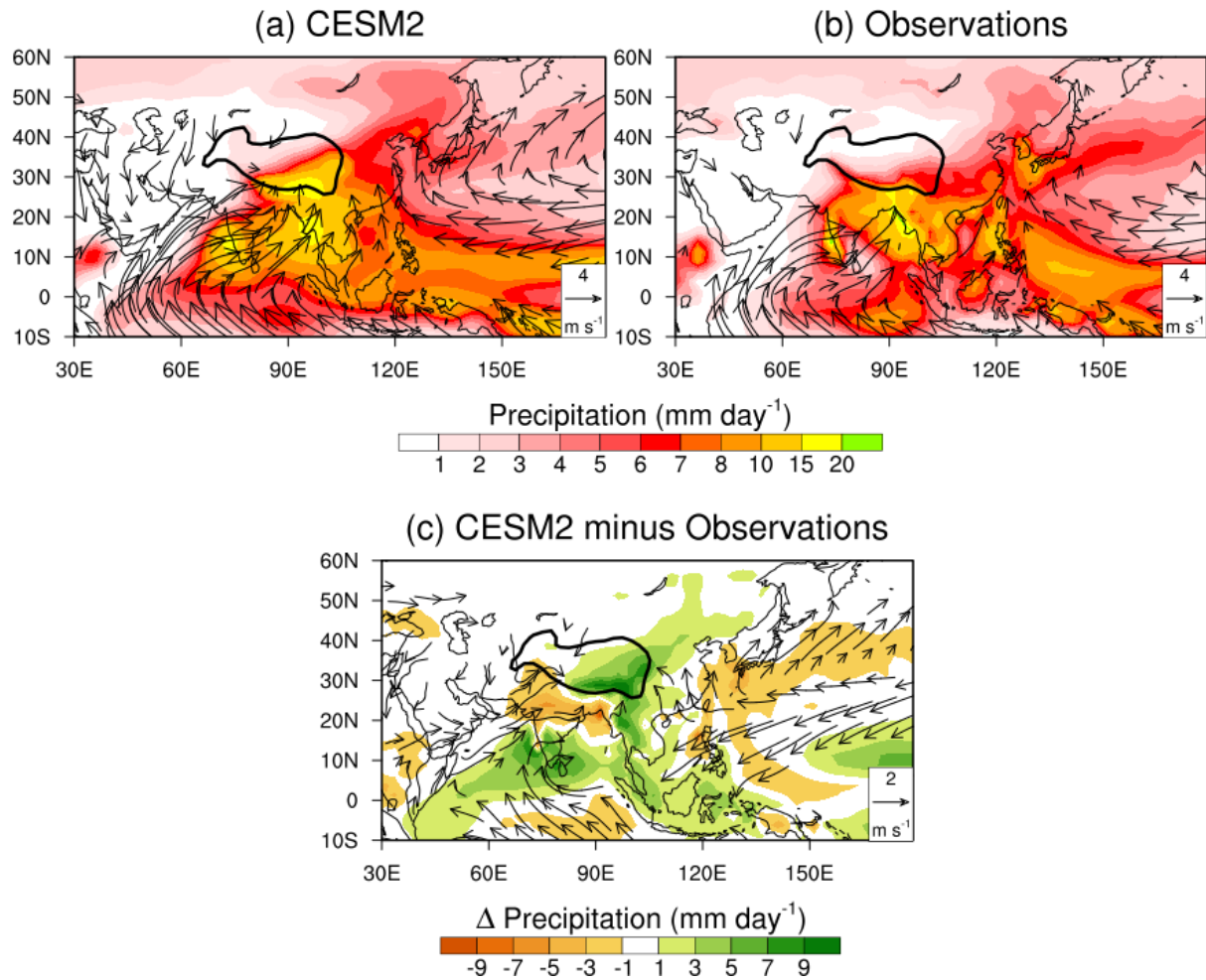
[3]Department of Atmospheric Sciences, Pusan National University, Busan, South Korea

[4]Institute for Future Earth, Pusan National University, Busan, South Korea

Extended Data Table 1. | Configuration of CESM2 experiments. Summary of experimental setups used to investigate the thermal and mechanical effects of the Tibetan Plateau, including removing sea surface temperature (SST) feedback. **Full-Tibet** represents the control experiment with present-day topography. **No-Tibet** removes the Tibetan Plateau entirely to evaluate the combined effects of thermal and mechanical effects. **Temp-Nudged-Tibet** applies atmospheric temperature nudging over the Tibetan Plateau to isolate the elevated thermal effect. The **_fixedSST** experiments involve Atmospheric-Only simulations, where SST is fixed to the climatological values derived from 2000s observed SST data, thereby eliminating SST feedback.
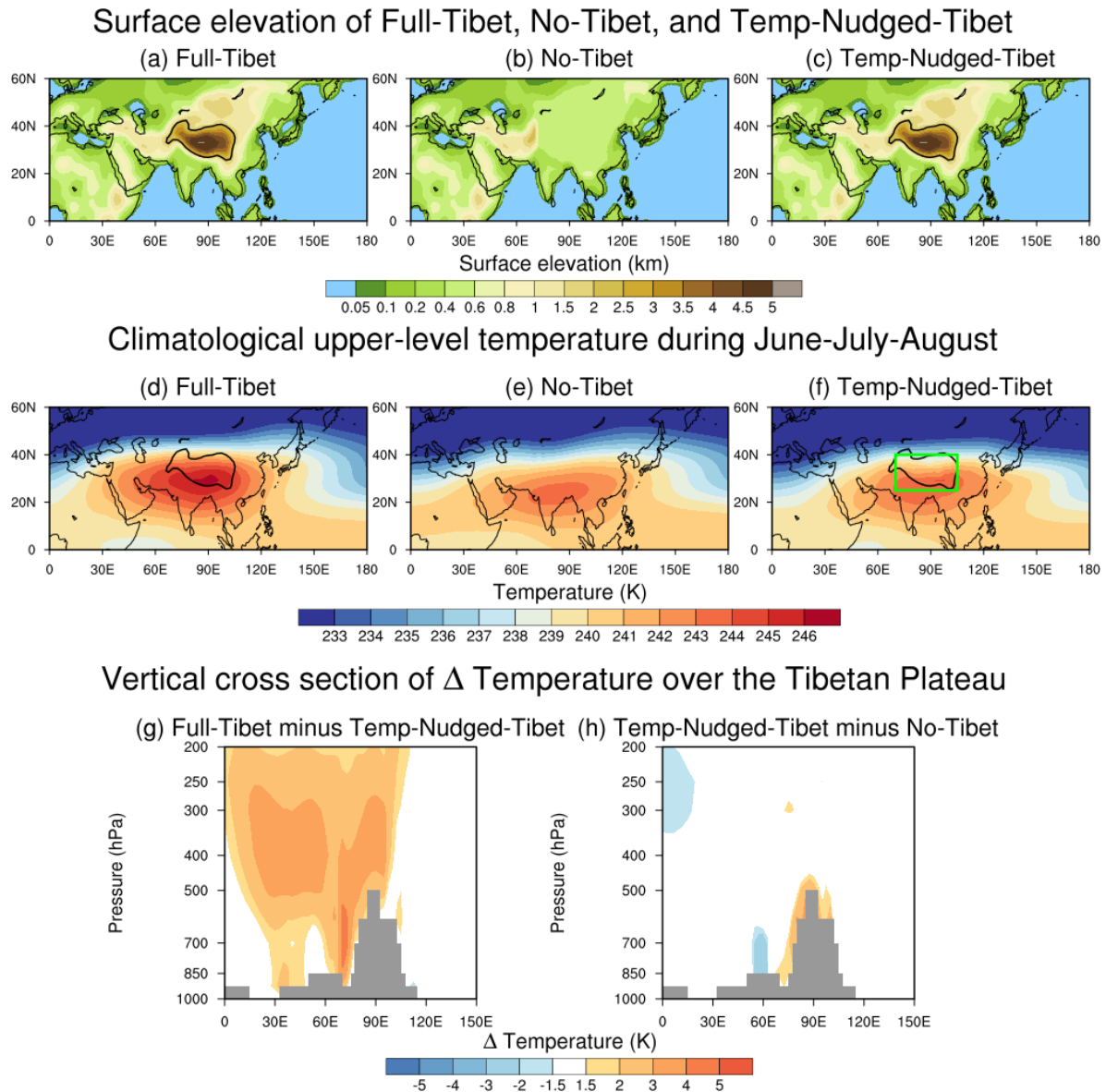
Experiments	Topography	Atmospheric temperature nudging over the Tibetan Plateau	Ocean coupling (SST feedback)
Full-Tibet	Full topography	OFF	ON
No-Tibet	Tibetan Plateau removed	OFF	ON
Temp-Nudged-Tibet	Full topography	ON	ON
Full-Tibet_fixedSST	Full topography	OFF	OFF
No-Tibet_fixedSST	Tibetan Plateau removed	OFF	OFF

Climatological precipitation during June-July-August

(a) CESM2

(b) Observations

Precipitation (mm day^{-1})

1 2 3 4 5 6 7 8 10 15 20

(c) CESM2 minus Observations

Δ Precipitation (mm day^{-1})

-9 -7 -5 -3 -1 1 3 5 7 9

Extended Data Fig. 1 | Asian summer precipitation. Climatological precipitation (shading; mm day^{-1}) and surface winds (arrows), averaged over June-July-August, for the **(a)** CESM2 Control simulation, and **(b)** GPCP precipitation and surface winds from the ERA5 dataset (1979-2022). **(c)** The difference between the CESM2 simulation and the observations.

Surface elevation of Full-Tibet, No-Tibet, and Temp-Nudged-Tibet

(a) Full-Tibet   (b) No-Tibet   (c) Temp-Nudged-Tibet

Surface elevation (km)

Climatological upper-level temperature during June-July-August

(d) Full-Tibet   (e) No-Tibet   (f) Temp-Nudged-Tibet

Temperature (K)

Vertical cross section of Δ Temperature over the Tibetan Plateau

(g) Full-Tibet minus Temp-Nudged-Tibet (h) Temp-Nudged-Tibet minus No-Tibet

Δ Temperature (K)

34

Extended Data Fig. 2 | Surface elevation and upper troposphere temperature over the Tibetan Plateau. (a-c) Surface elevation for the **(a)** Full-Tibet, **(b)** No-Tibet, and **(c)** Temp-Nudged-Tibet experiments. In the No-Tibet experiment, the topography over the Tibetan Plateau is reduced to 500 m. (d-f) Climatological upper-level temperature (K), averaged over 175-450 hPa, during June-July-August, for the **(d)** Full-Tibet, **(e)** No-Tibet, and **(f)** Temp-Nudged-Tibet experiments. The green box in (f) indicates the atmospheric temperature nudging area (25°-43°N, 65°-100°E). (g-h) Vertical cross-section of atmospheric temperature changes over the Tibetan Plateau (meridional mean over 28°-35°N): **(g)** difference between the Full-Tibet and Temp-Nudged-Tibet experiments, and **(h)** difference between the Temp-Nudged-Tibet and No-Tibet experiments.

45