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Data availability. All data used in this work are freely available for research purposes.

Author contributions. All authors designed the analysis and wrote the paper. LJW, ZL, BHS, EH, MTL, KN, and SU performed the analysis.

Competing interests. The authors declare that they have no conflict of interest.

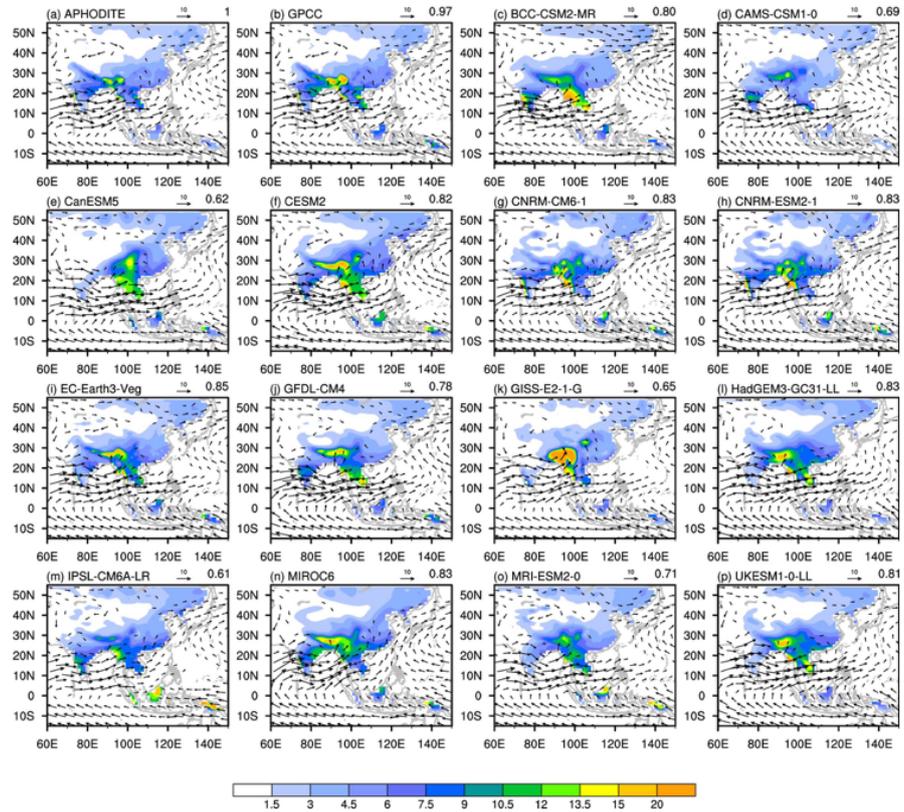


Figure 1. 1980-2014 JJAS mean precipitation and 850hPa winds from (a): APHODITE and ERA-Interim; (b): GPCC and ERA-Interim; (c)-(p): Individual CMIP6 models.

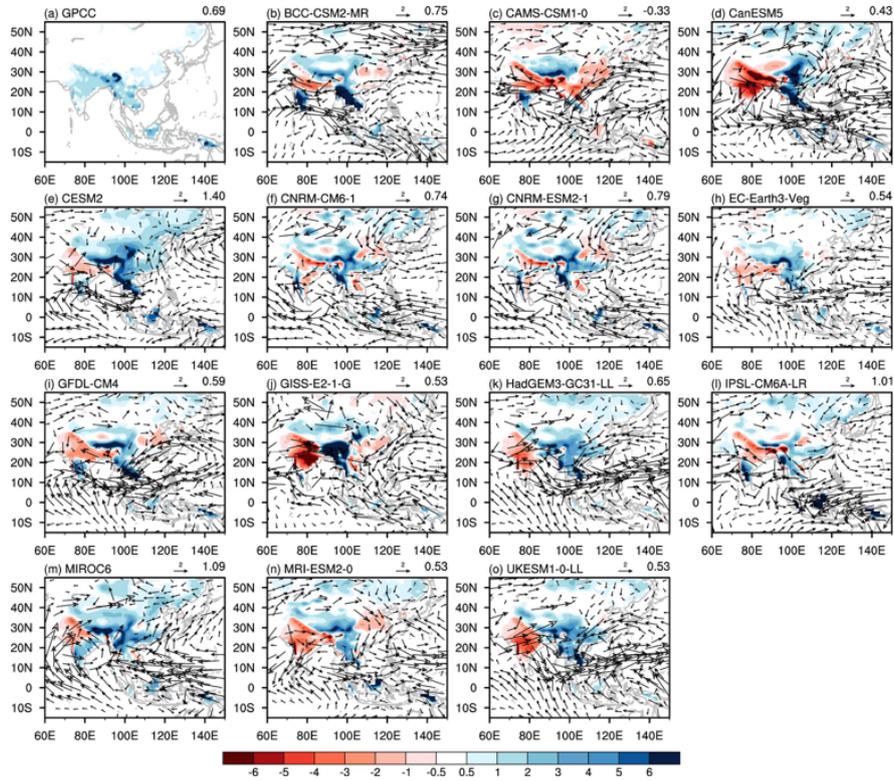


Figure 2. 1980-2014 JJAS mean precipitation relative to APHRODITE and 850hPa winds relative to ERA-Interim from (a): GPCC and ERA-Interim; (b)-(o): Individual CMIP6 models.

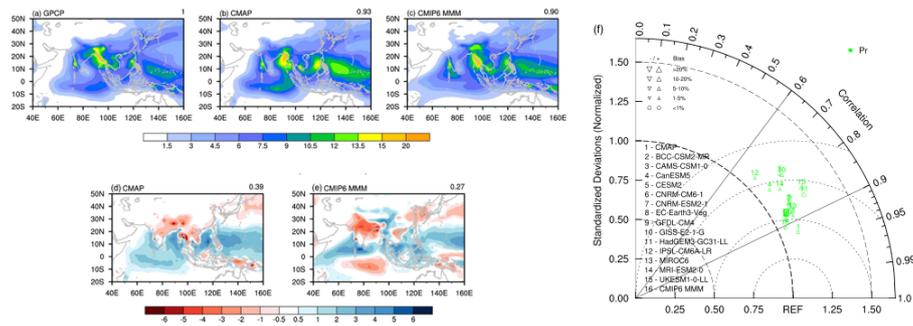


Figure 3. JJAS mean 1980-2014 mean precipitation overlaid with 850 hPa wind from (a): GPCP and ERA-Interim; (b): CMAP and ERA-Interim; (c): CMIP6 (multi-model mean). Values in the top right corner show the pattern correlation with APHRODITE precipitation. (d): Precipitation bias in CMAP relative to GPCP; (e): CMIP6 precipitation relative to GPCP and CMIP6 850 hPa winds relative to ERA-Interim. (f): Taylor diagram showing the relationship between individual CMIP6 models, the CMIP6 multi-model mean (point 16), and CMAP (point 1), with GPCP precipitation. The model number within a solid square indicates the model with the smallest absolute bias (EC-Earth3-Veg).

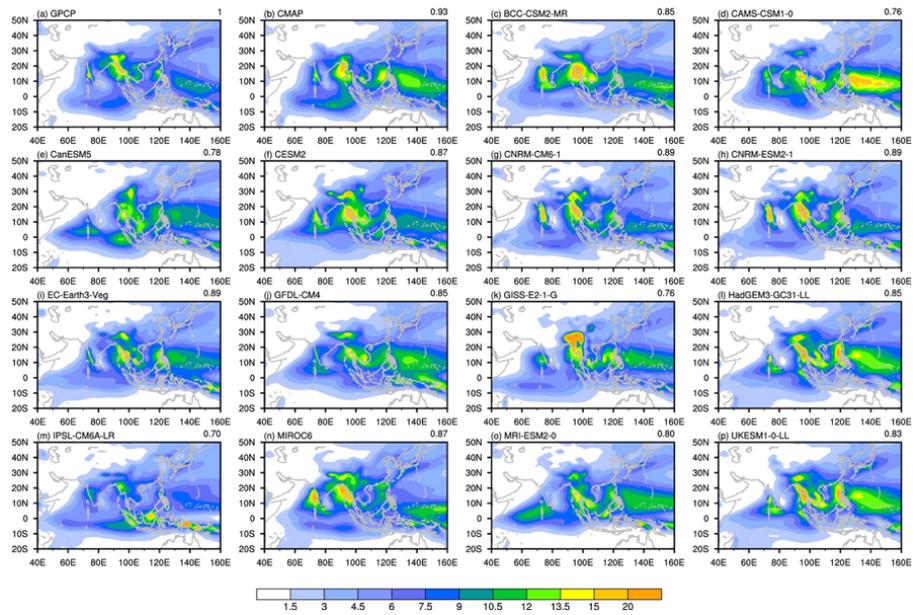


Figure 4. 1980-2014 JJAS mean precipitation from (a): GPCP; (b): CMAP; (c)-(p): Individual CMIP6 models.

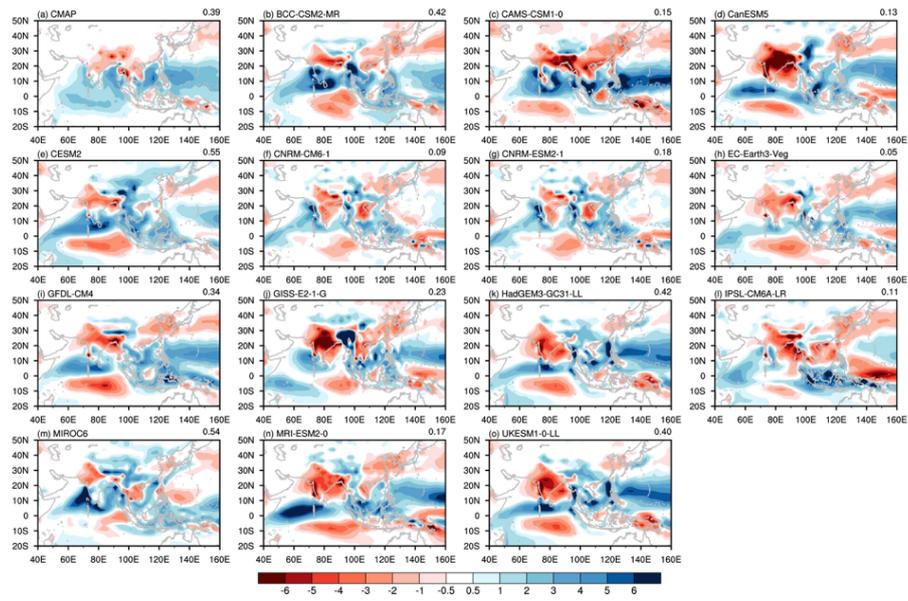


Figure 5. 1980-2014 JJAS mean precipitation relative to GPCP from (a): CMAP; (b)-(o): Individual CMIP6 models.

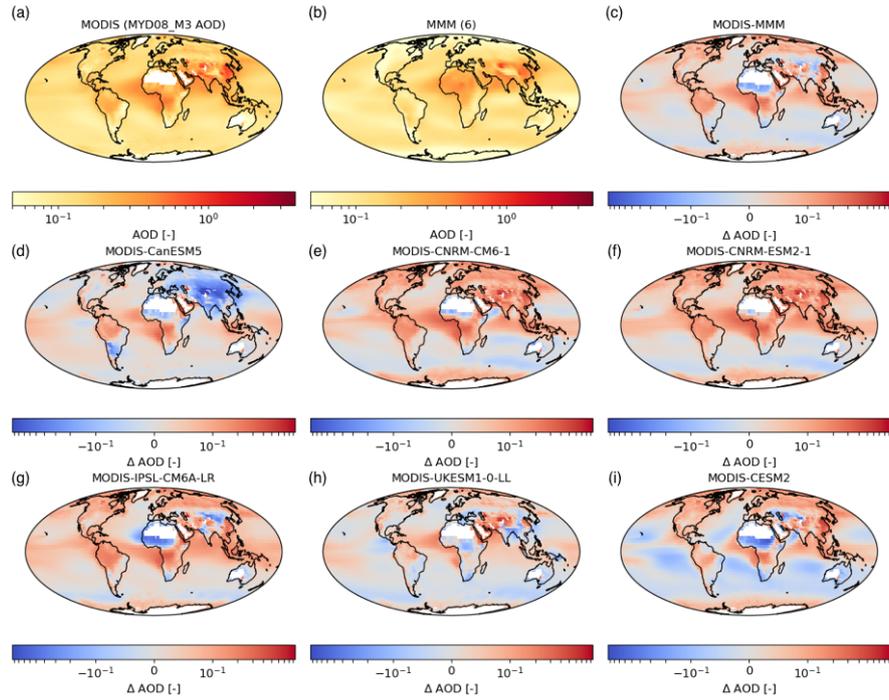


Figure 6. (a): 2002-2014 mean aerosol optical depth at 550 nm from MODIS; (b): 2002-2014 mean CMIP6 multi-model mean aerosol optical depth at 550 nm; (c): CMIP6 bias relative to MODIS, (d)-(i): Individual CMIP6 model biases relative to MODIS.

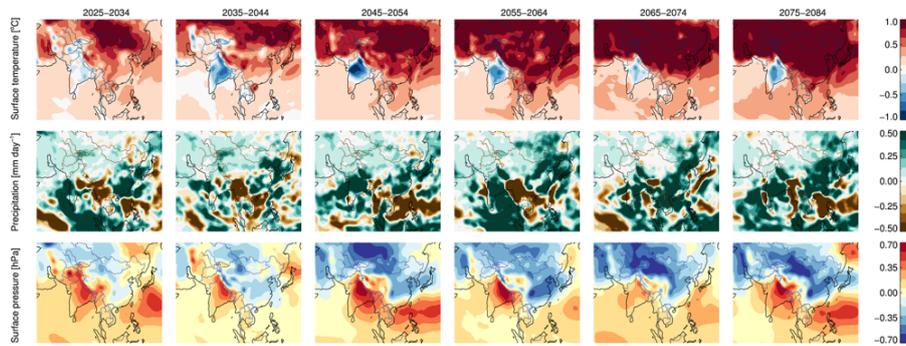


Figure 7. JJAS (a): near-surface temperature [K]; (b): precipitation [mm day^{-1}]; and (c): sea level pressure [hPa] anomalies for 10 year periods vs. 1980-2014 from an anthropogenic aerosol only version of SSP2-4.5 (SSP2-4.5-aer) with MIROC6.

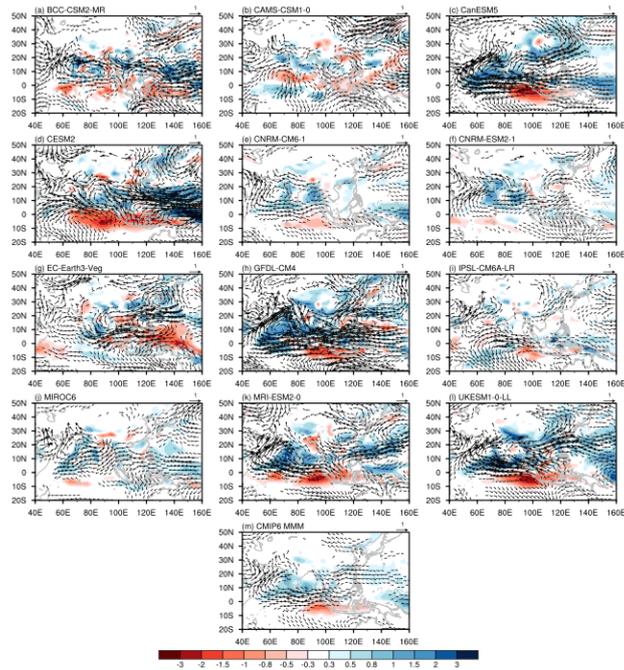


Figure 8. JJAS precipitation and 850 hPa wind anomalies for SSP2-4.5 2035-2044 vs. 1980-2014 for (a)-(l): Individual CMIP6 models; (m): The CMIP6 multi-model mean.