Supplementary Information for

Recent Southwestern U.S. drought influenced by anthropogenic aerosols and tropical ocean warming

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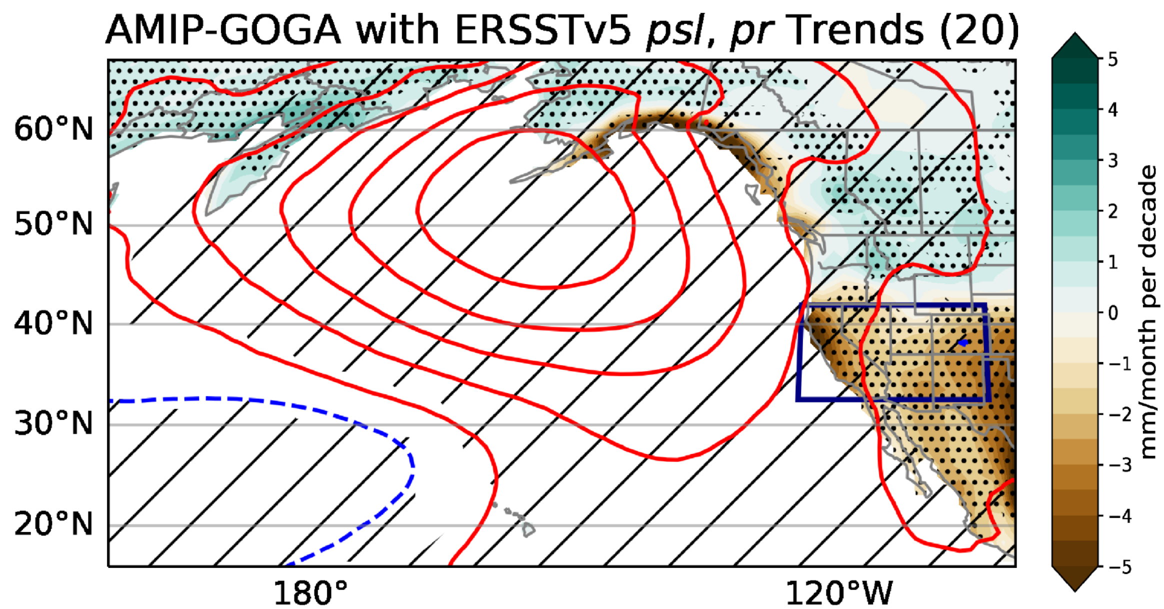
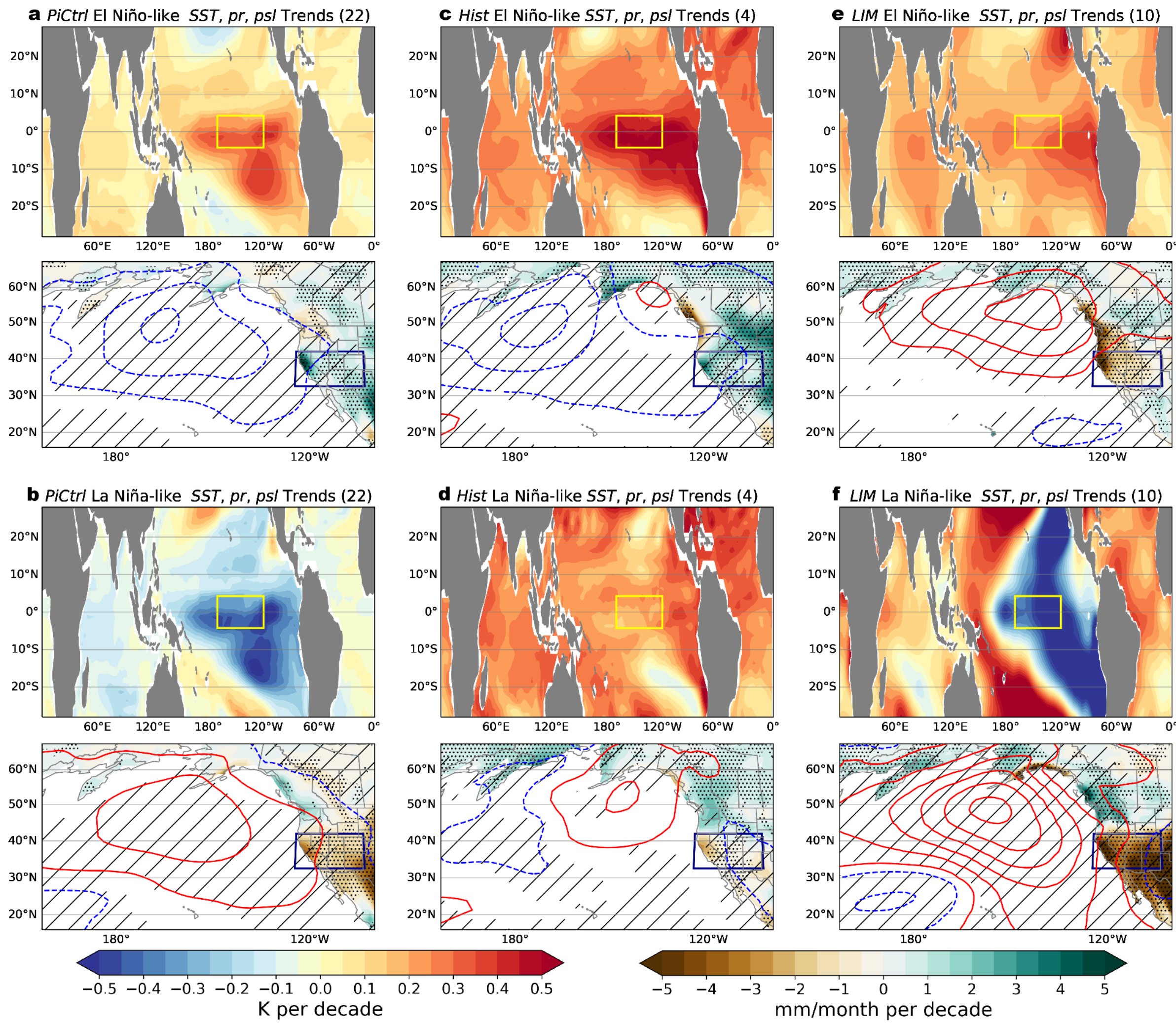


Figure. S1. Sea level pressure and precipitation trends over 1980-2014 from global ocean global atmosphere (GOGA) experimental set-up (i.e., standard AMIP experiment). *This figure consists of data from two 10-member atmosphere-land models (10 members CAM6/CLM5 (CESM2), 10 members UM7.3/CABLE (ACCESS-ESM1.5)). The Hatching/Stippling indicates 67% of the ensemble members agree with the sign of ensemble mean trend.*



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24 ***Figure S2. Same as Fig. 2c-2g but from ACCESS-ESM1.5.***

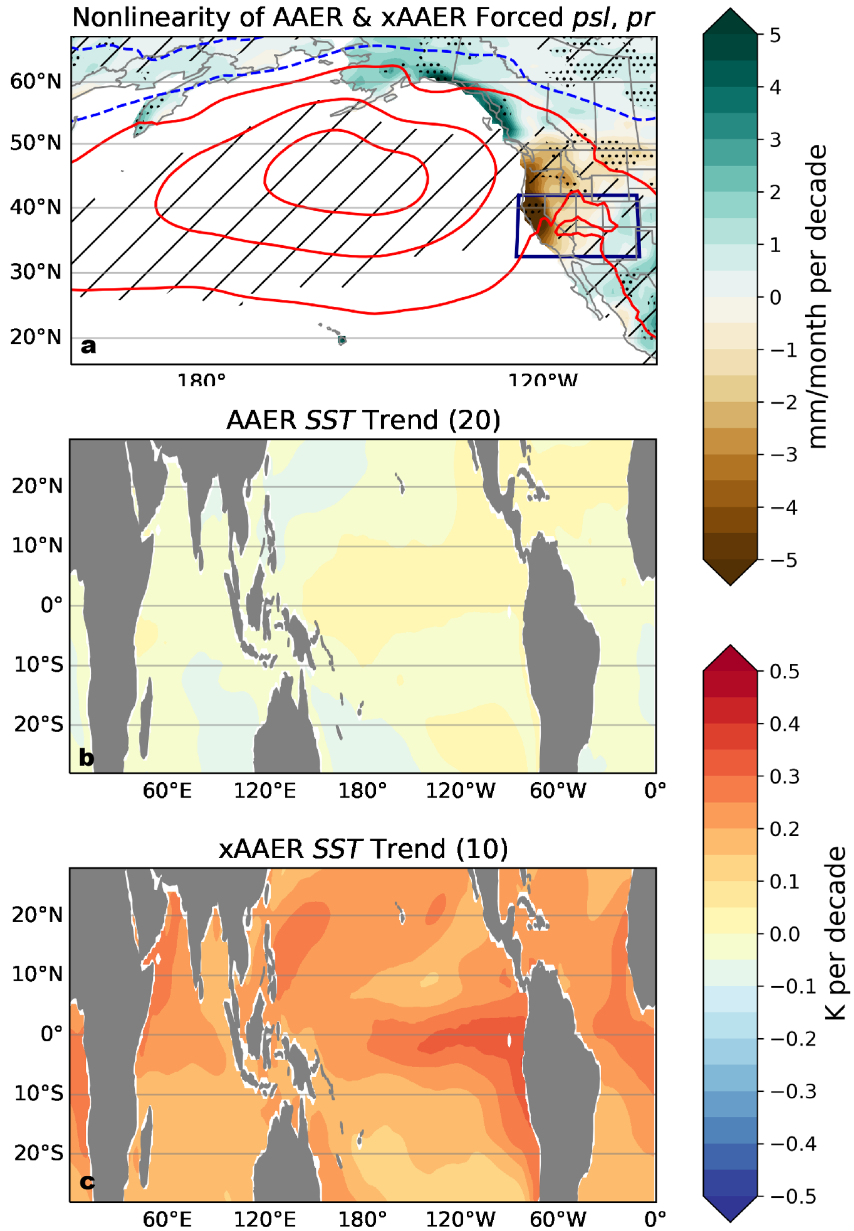

***Figure S3. Nonlinear DJFMAM trends in fully coupled large ensemble and single forcing simulations. a**, The nonlinear response of psl and pr trends from the Anthropogenic Aerosols (AAER) and everything-but-anthropogenic aerosols (xAAER) forcing simulations. The nonlinearity is calculated as the difference between the all forcing large ensemble (Fig. 1g) and the sum of the AAER (Fig. 3e) and xAAER (Fig. 3f). The tropical SST trend from **b**, AAER, and **c**, xAAER simulations.*

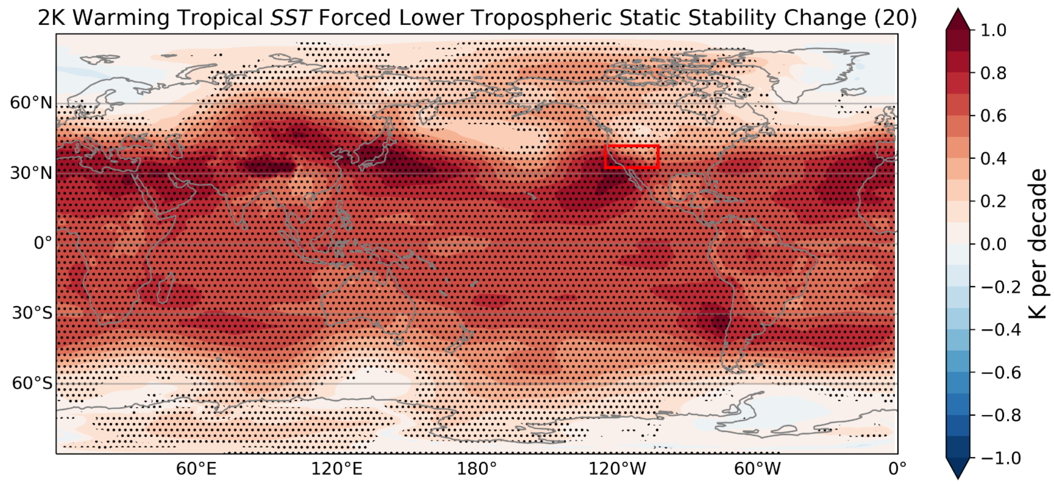

Figure S4. DJFMAM lower tropospheric static stability change under 2K uniform tropical warming. *The lower tropospheric static stability is defined as the difference of the potential temperatures at 700hPa and at the surface. Stippling indicates 67% of the ensemble members agree with the sign of ensemble mean change.*

Table S1. CMIP6 models used in this study. *We used all the r1i1p1f1 from models that provided historical and four SSP scenarios (ssp126, ssp245, ssp370, and ssp585) experiments for all the variables used in this study (tos, tas, pr, psl, mrsos). We also include the last 300 years from the piControl simulation from all the models except FGOALS-f3-L and KACE-1-0-G, as their piControl simulation does not have mrsos output on the CMIP6 archive.*

Model name	PiControl	Historical	SSP126	SSP245	SSP370	SSP585
ACCESS-CM2	v	v	v	v	v	v
ACCESS-ESM1.5	v	v	v	v	v	v
BCC-CSM2-MR	v	v	v	v	v	v
CESM2-WACCM	v	v	v	v	v	v
CESM2	v	v	v	v	v	v
CMCC-CM2-SR5	v	v	v	v	v	v
CMCC-ESM2	v	v	v	v	v	v
CanESM5	v	v	v	v	v	v
EC-Earth3	v	v	v	v	v	v
FGOALS-f3-L		v	v	v	v	v
FGOALS-g3	v	v	v	v	v	v
GFDL-ESM4	v	v	v	v	v	v
IPSL-CM6A-LR	v	v	v	v	v	v
KACE-1-0-G		v	v	v	v	v
MIROC6	v	v	v	v	v	v
MPI-ESM1-2-LR	v	v	v	v	v	v
MRI-ESM2-0	v	v	v	v	v	v

Sea Surface Temperatures (SSTs) generated by a Cyclostationary Linear Inverse Model (CS-LIM)

The globally extended version of CS-LIM[39] is used to generate a large ensemble of a 60-year SST dataset. The CS-LIM was constructed by using monthly sea surface temperature (SST) and sea surface height (SSH) anomalies at 2°x2° spatial resolution derived from the NOAA ERSSTv5[66] and ECMWF ORAS4[81] over the ice-free global ocean during the years 1958-2017. Anomalies were obtained by removing the long-term mean, the mean seasonal cycle, and the long-term trend (identified by the least damped mode of the system via stationary empirical normal mode analysis[82]). Then, the EOFs representing the dominant patterns of variability and the PCs representing the time-evolving amplitudes of these patterns were estimated. The leading 13 (9) PCs of SST (SSH) anomalies were used, which explains 62.5% (64.3%) of the total variance. This combination of PCs was chosen to represent the variability realistically while producing reasonably skillful hindcasts of ENSO and PDO in a cross-validation sense.

The CS-LIM has been integrated numerically for 6,100 years, from which the last 6,000 years are used to generate 100 60-year segments of natural climate variability[39]. The segments differ regarding the initial state of SST and SSH anomalies and stochastic forcing realizations. The total SST and SSH anomalies were then estimated by adding the predefined long-term trend (see above) to the anomalous natural climate variability.