Supplementary Information for Fast jet stream winds get faster under climate change

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Table 1 CMIP6 models analyzed in this study.

Model	*realization*	*scenario*
ACCESS-CM2	r1i1p1f1	historical, SSP5-8.5
BCC-CSM2-MR	r1i1p1f1	historical, SSP5-8.5, amip, amip-p4K
CanESM5	r1i1p1f1	historical, SSP5-8.5
CESM2-WACCM	r1i1p1f1	historical, SSP5-8.5, amip, amip-p4K, aqua, aqua-p4K
FGOALS-g3	r1i1p1f1	historical, SSP5-8.5
GFDL-CM4	r1i1p1f1	historical, SSP5-8.5
IITM-ESM	r1i1p1f1	historical, SSP5-8.5
INM-CM4-8	r1i1p1f1	historical, SSP5-8.5
INM-CM5-0	r1i1p1f1	historical, SSP5-8.5
IPSL-CM6A-LR	r1i1p1f1	historical, SSP5-8.5, amip, amip-p4K, aqua, aqua-p4K
KACE-1-0-G	r1i1p1f1	historical, SSP5-8.5
MIROC6	r1i1p1f1	historical, SSP5-8.5, amip, amip-p4K, aqua, aqua-p4K
MPI-ESM1-2-LR	r1i1p1f1	historical, SSP5-8.5
MPI-ESM1-2-HR	r1i1p1f1	historical, SSP5-8.5
MRI-ESM2-0	r1i1p1f1	historical, SSP5-8.5, amip, amip-p4K, aqua, aqua-p4K
NorESM2-LM	r1i1p1f1	historical, SSP5-8.5
NorESM2-MM	r1i1p1f1	historical, SSP5-8.5
TaiESM1	r1i1p1f1	historical, SSP5-8.5, amip, amip-p4K, aqua, aqua-p4K

Table 2 CMIP5 models analyzed in this study.

Model	*realization*	*scenario*
ACCESS1-3	r1i1p1	historical, RCP8.5
bcc-csm1-1	r1i1p1	historical, RCP8.5
bcc-csm1-1-m	r1i1p1	historical, RCP8.5
BNU-ESM	r1i1p1	historical, RCP8.5
CanESM2	r1i1p1	historical, RCP8.5
CCSM4	r1i1p1	historical, RCP8.5
CMCC-CESM	r1i1p1	historical, RCP8.5
CMCC-CMS	r1i1p1	historical, RCP8.5
CNRM-CM5	r1i1p1	historical, RCP8.5
GFDL-CM3	r1i1p1	historical, RCP8.5
GFDL-ESM2G	r1i1p1	historical, RCP8.5
GFDL-ESM2M	r1i1p1	historical, RCP8.5
IPSL-CM5A-LR	r1i1p1	historical, RCP8.5
MIROC-ESM	r1i1p1	historical, RCP8.5
MIROC-ESM-CHEM	r1i1p1	historical, RCP8.5
MIROC5	r1i1p1	historical, RCP8.5
MRI-ESM1	r1i1p1	historical, RCP8.5
NorESM1-M	r1i1p1	historical, RCP8.5

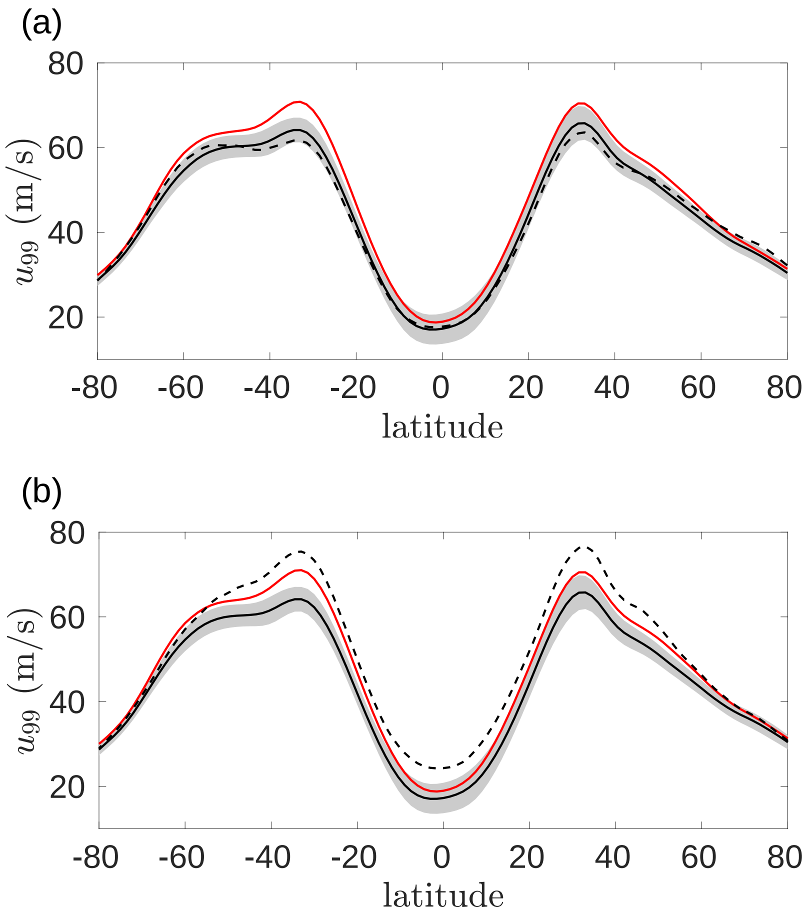

Fig. 1 Fastest jet stream winds in reanalysis data and climate models. The fastest ($\geq$ 99th percentile) daily upper level (200 hPa) jet stream (zonal) winds for historical (1980 to 2000, black) and future (2080 to 2100, red) climates for coupled climate models (solid) and reanalysis data (dashed) on (a) coarse grained grid (see Methods) and (b) original grid. Shading indicates one standard deviation of the response across the model ensemble.

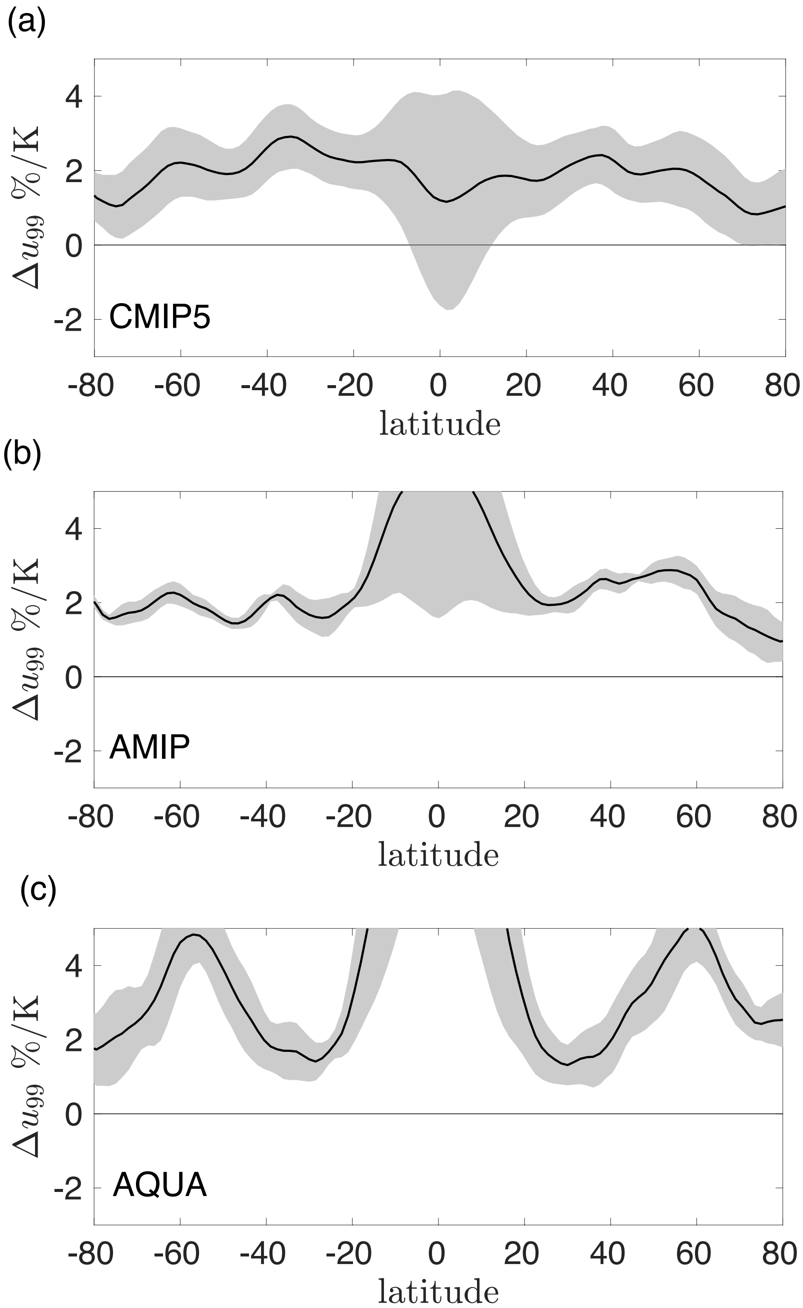

Fig. 2 Fastest jet stream winds under climate change across a model hierarchy. Fractional changes in the fastest ($\geq$ 99th percentile) jet stream winds normalized by the global mean surface temperature increase for each model for (a) CMIP5 RCP8.5 (2080 to 2100) minus historical (1980 to 2000) coupled climate models, (b) CMIP6 amip-p4K minus amip, and (c) CMIP6 aqua-p4K minus aqua. Shading indicates one standard deviation of the response across the model ensemble.

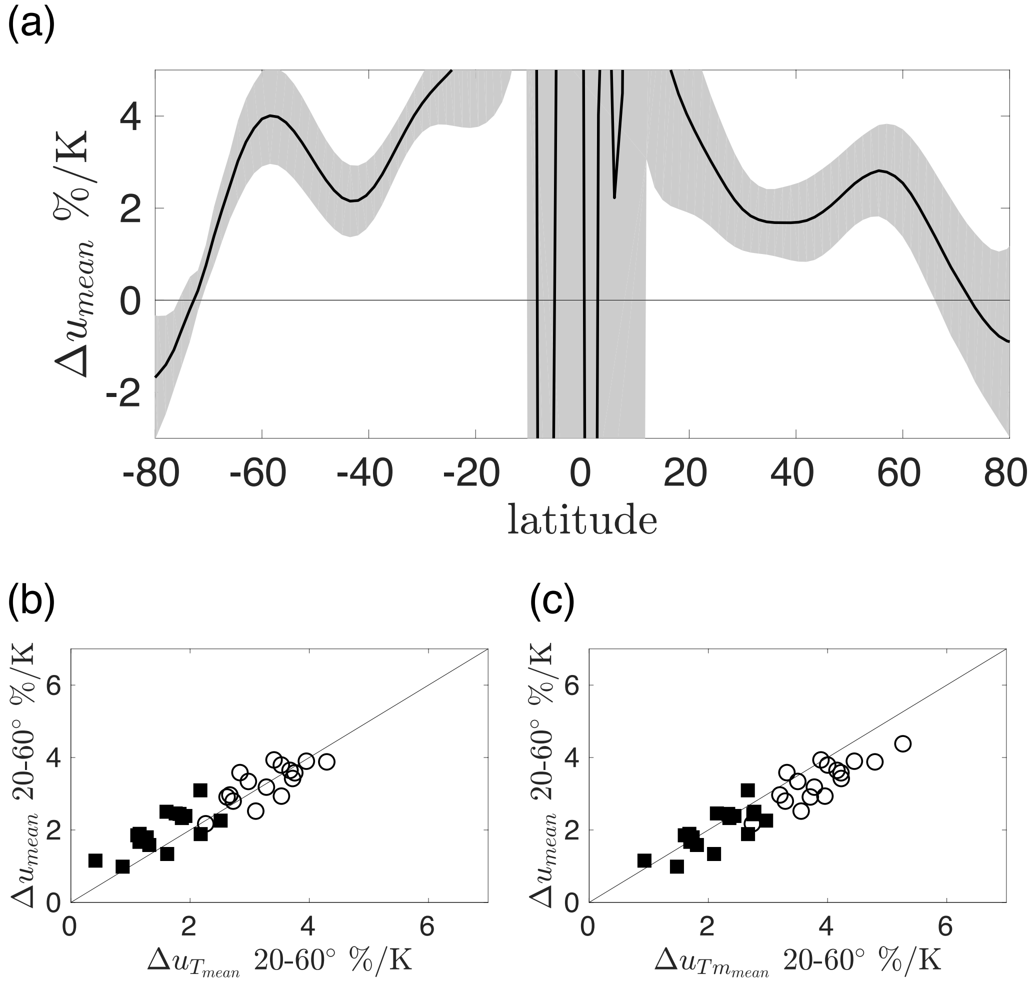

Fig. 3 Average jet stream winds under climate change. (a) Fractional changes in the average daily upper level zonal winds normalized by the global mean surface temperature increase for each model. Shading indicates one standard deviation of the response across coupled models. Fractional changes in the average daily upper level zonal winds normalized by the global mean surface temperature increase for each model versus (a) thermal wind (equation (1)) and (b) moist thermal wind (equation (2)) averaged over the extratropics (20-60° latitude). Northern Hemisphere values from individual models are shown by squares and Southern Hemisphere values are shown by circles.

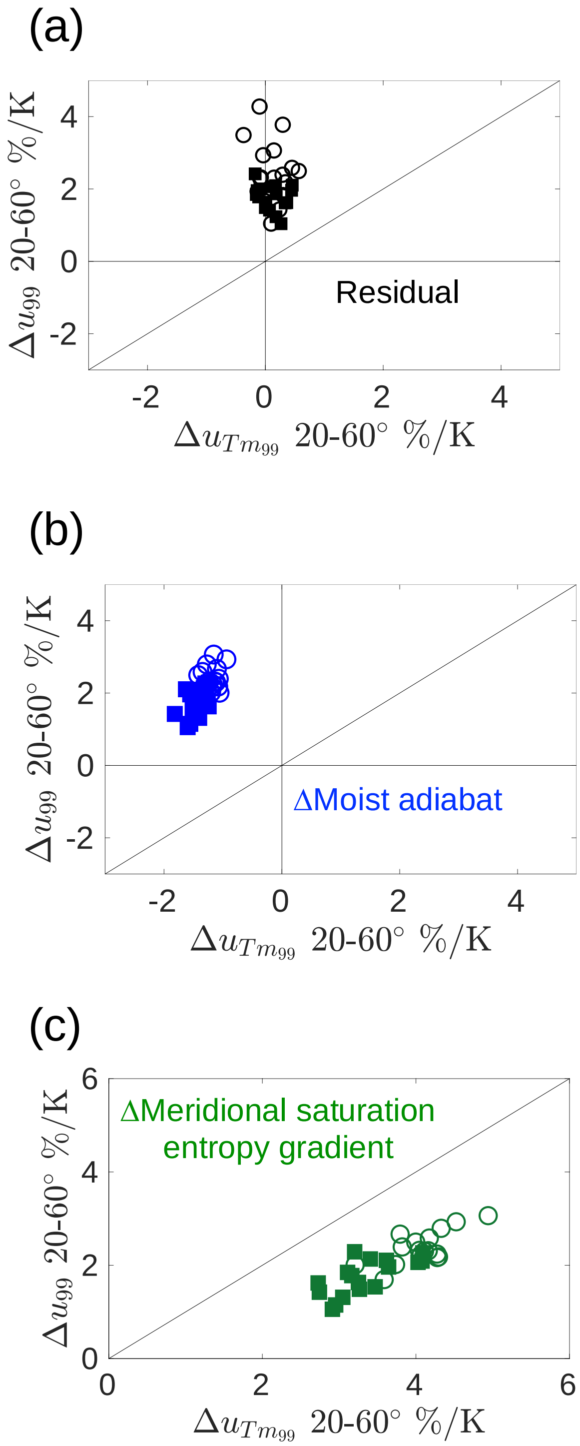

Fig. 4 Relationship between the fastest jet stream winds and moisture under climate change. Fractional changes in the fastest ($\geq$ 99th percentile) jet stream winds versus fastest moist thermal wind decomposed into (a) residual, (b) poleward saturation entropy gradient and (c) moist adiabat [equation (3)] averaged over the extratropics (20-60° latitude). Northern Hemisphere values from individual models are shown by squares and Southern Hemisphere values are shown by circles.

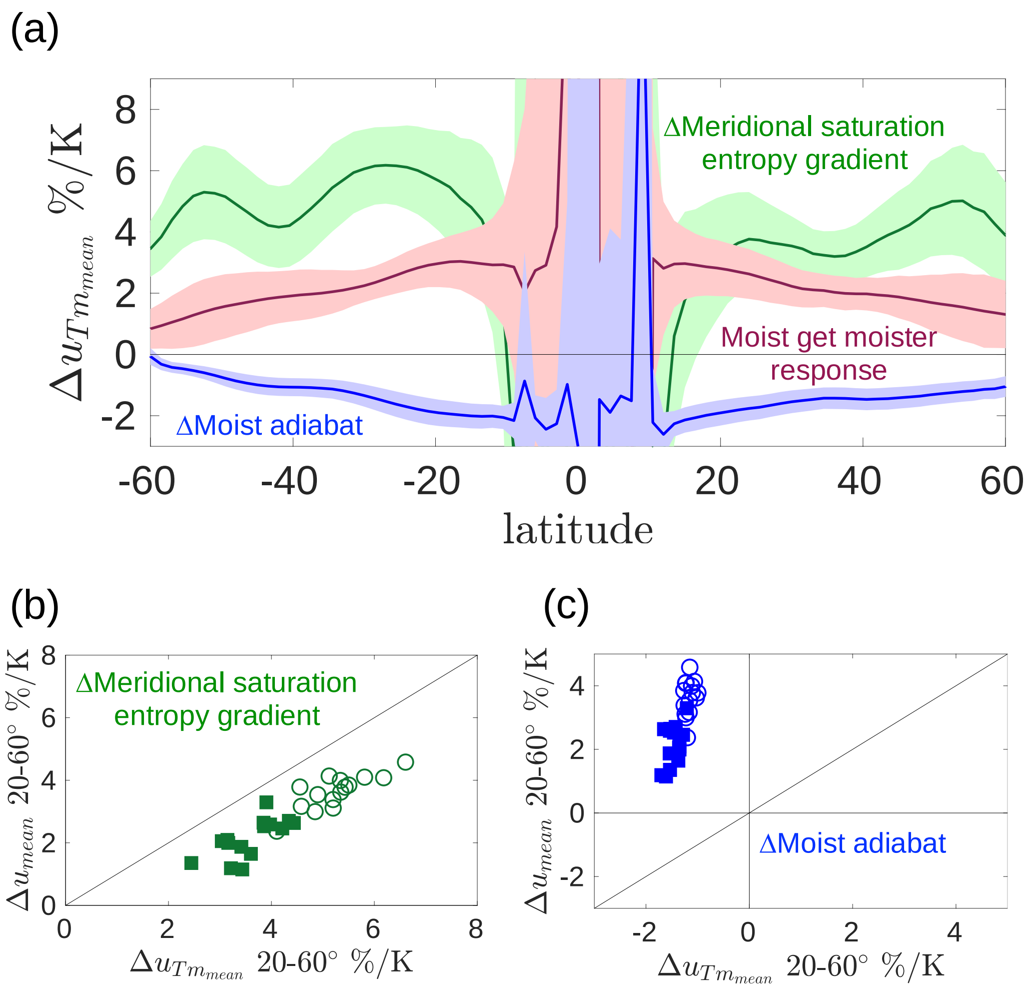

Fig. 5 Relationship between the average jet stream winds and moisture under climate change. (a) Fractional changes in moist thermal wind decomposed into contributions from changes in poleward saturation entropy gradient (green), moist get moister response (meridional saturation entropy gradient following Clausius-Clapeyron with no change in meridional temperature gradient, maroon) and moist adiabat (blue) normalized by the global mean surface temperature increase for each model. Shading indicates one standard deviation of the response across the model ensemble. Fractional changes in the average jet stream winds averaged over the midlatitudes normalized by the global mean surface temperature increase for each model versus moist thermal wind decomposed into contributions from (b) poleward saturation entropy gradient and (c) moist adiabat [equation (3)]. Northern Hemisphere values from individual models are shown by squares and Southern Hemisphere values are shown by circles.

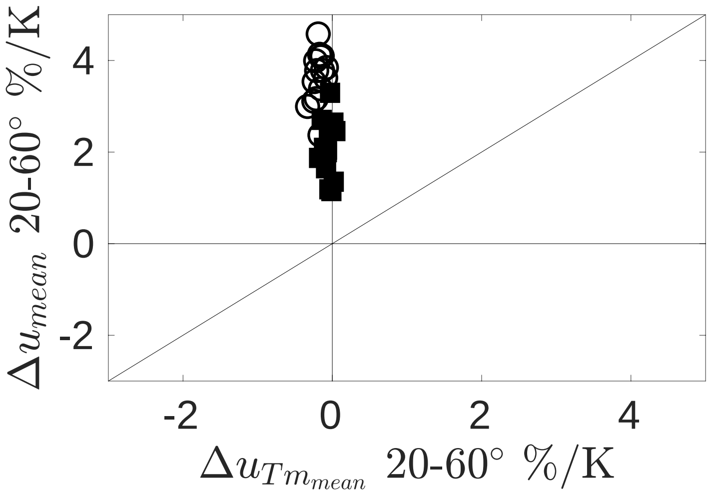

Fig. 6 Residual of moist thermal wind decomposition for average jet stream wind. Fractional changes in average moist thermal wind residual [equation (3)]. Northern Hemisphere values from individual models are shown by squares and Southern Hemisphere values are shown by circles.