Supporting Information for "Elucidating the mechanisms responsible for Hadley cell weakening under $4 \times CO_2$ forcing"

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Table S1. List of the 20 CMIP5 models analyzed in this study.

	Model	**Modeling Center**
1	ACCESS1.0	CSIRO (Commonwealth Scientific and Industrial Research Organisation, Australia), and BOM (Bureau of Meteorology, Australia)
2	BCC-CSM1-1	Beijing Climate Center, China Meteorological Administration
3	bcc-csm1-1-m	Beijing Climate Center, China Meteorological Administration
4	CanESM2	Canadian Centre for Climate Modelling and Analysis
5	CCSM4	National Center for Atmospheric Research
6	CNRM-CM5	Centre National de Recherches Meteorologiques / Centre Europeen de Recherche et Formation Avancees en Calcul Scientifique
7	CSIRO-Mk3-6-0	Commonwealth Scientific and Industrial Research Organisation in collaboration with the Queensland Climate Change Centre of Excellence
8	FGOALS-g2	LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences; and CESS, Tsinghua University
9	GFDL-CM3	Geophysical Fluid Dynamics Laboratory
10	GFDL-ESM2G	Geophysical Fluid Dynamics Laboratory
11	GFDL-ESM2M	Geophysical Fluid Dynamics Laboratory
12	GISS-E2-H	NASA Goddard Institute for Space Studies
13	GISS-E2-R	NASA Goddard Institute for Space Studies
14	HadGEM2-ES	Met Office Hadley Centre (additional HadGEM2-ES realizations contributed by Instituto Nacional de Pesquisas Espaciais)
15	INMCM4	Institute for Numerical Mathematics
16	IPSL-CM5A-LR	Institut Pierre-Simon Laplace
17	IPSL-CM5B-LR	Institut Pierre-Simon Laplace
18	MIROC5	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology
19	MRI-CGCM3	Meteorological Research Institute
20	NorESM1-M	Norwegian Climate Centre

	θ_y	θ_p	$\mathrm{OLR_y}$	$\mathrm{OLR} - \mathrm{Q_{srf}}$	$\mathrm{OLR}\theta_p^{-1}$
Pq^{-1}	-0.03	0.53	0.01	-0.04	**0.61**
$\mathrm{OLR}\theta_p^{-1}$	-0.11	**0.92**	-0.17	-0.22	
$\mathrm{OLR} - \mathrm{Q_{srf}}$	-0.05	-0.27	0.16		
$\mathrm{OLR_y}$	-0.21	-0.14			
θ_p	0.13				

Table 2. Cross-correlation of the quantities analyzed in this study. See Methods section in the main text for the definition of each quantity.

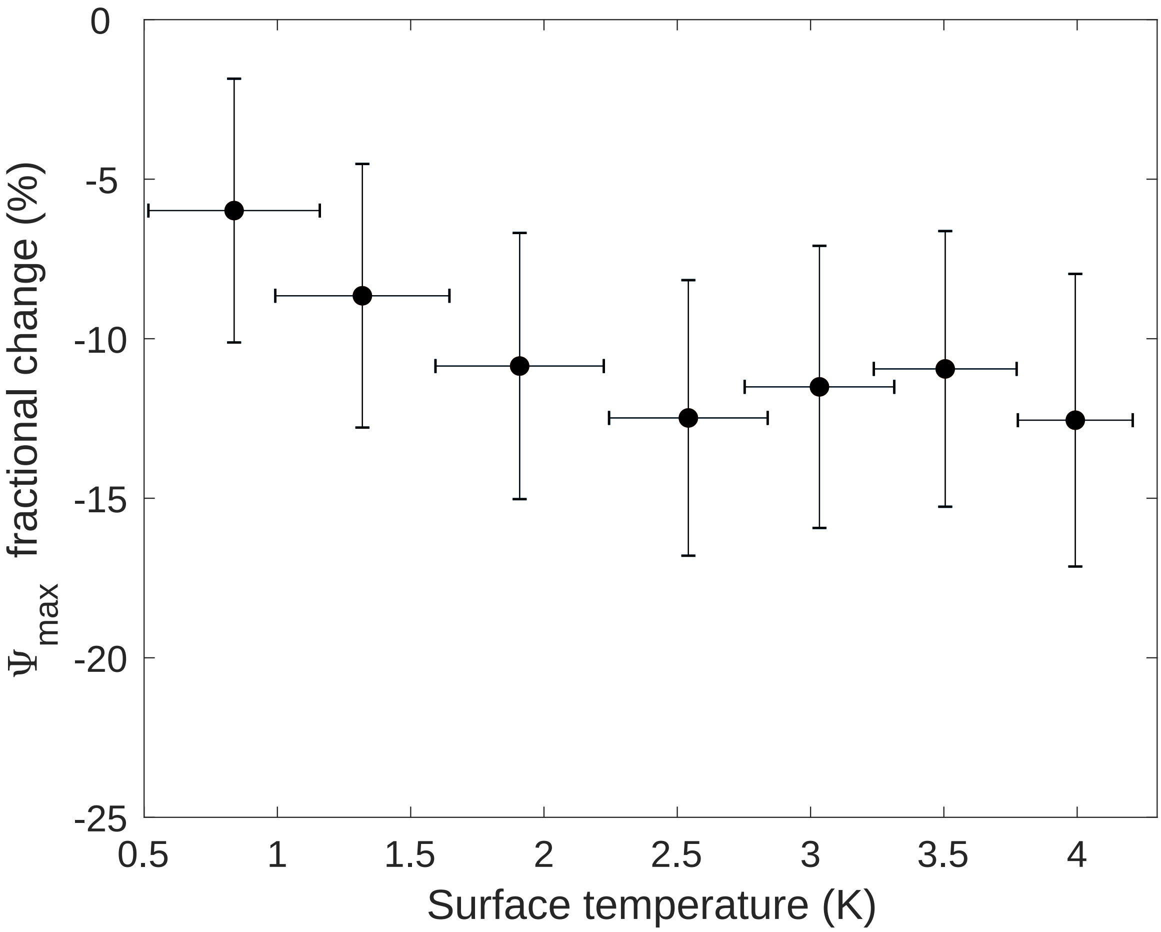

Figure S1. The fractional change (in %, relative to PI) in NH $\Psi_{\max}$ under the abrupt $4 \times CO_2$ forcing vs. the NH tropical mean surface temperature response (K). The error bars represent the 95% confidence interval calculated via Student's t-distribution across all models.

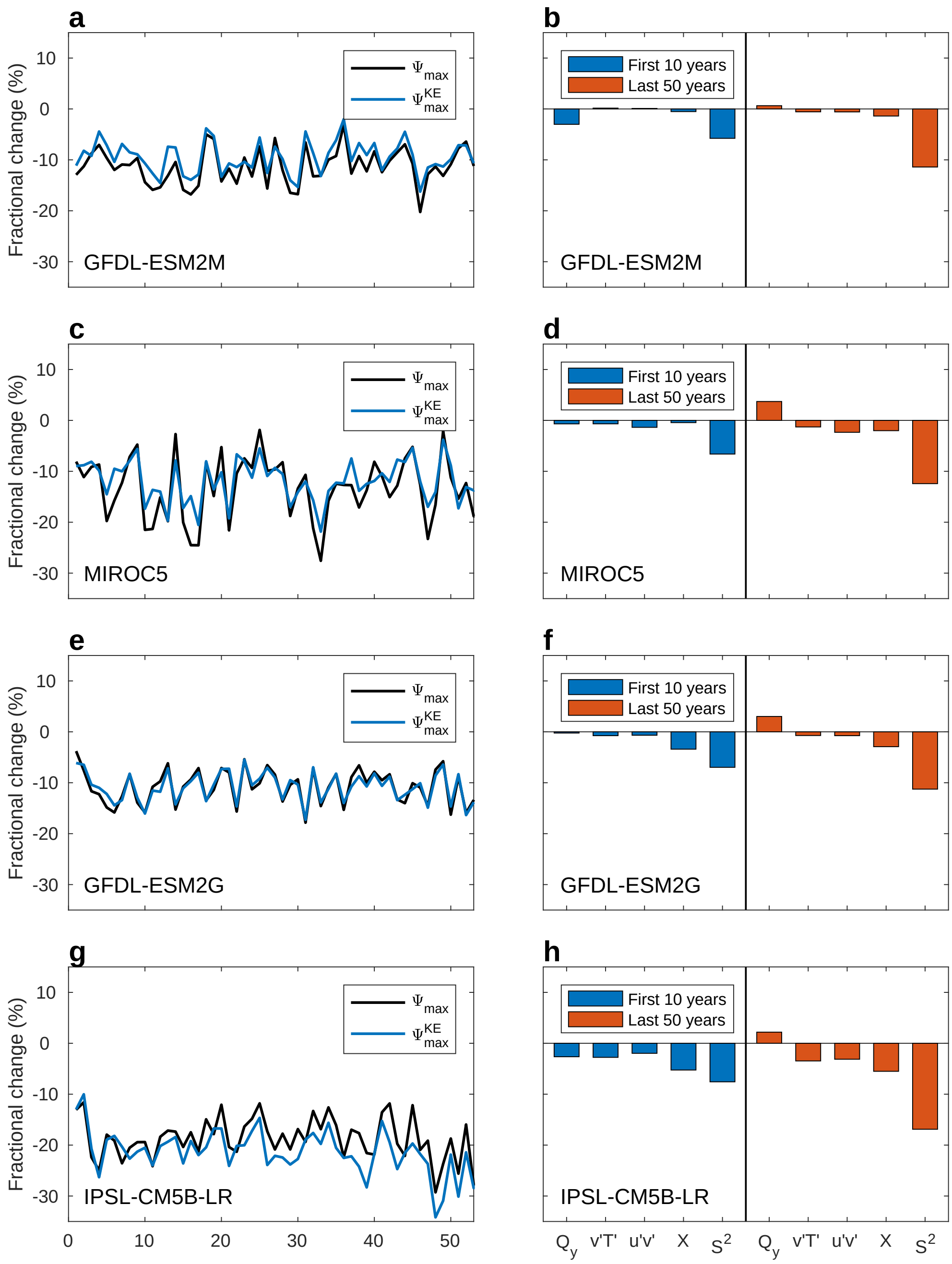

Figure S2. Time series of the fractional change (in %, relative to PI) of NH $\Psi_{\max}$ (black line) and $\Psi^{\mathrm{KE}}_{\max}$ (blue line) under the abrupt $4 \times \mathrm{CO_2}$ forcing in CMIP5 (left column), and the relative contributions to changes in $\Psi^{\mathrm{KE}}_{\max}$ (right column) from: diabatic heating ($\mathrm{Q_y}$), eddy heat fluxes (v′T′), eddy momentum fluxes (u′v′), zonal friction (X) and static stability (S^2). The blue and red bars show the relative contributions to the first 10 years and last 50 years fractional change in $\Psi^{\mathrm{KE}}_{\max}$, respectively. Each row shows the results form a different model.

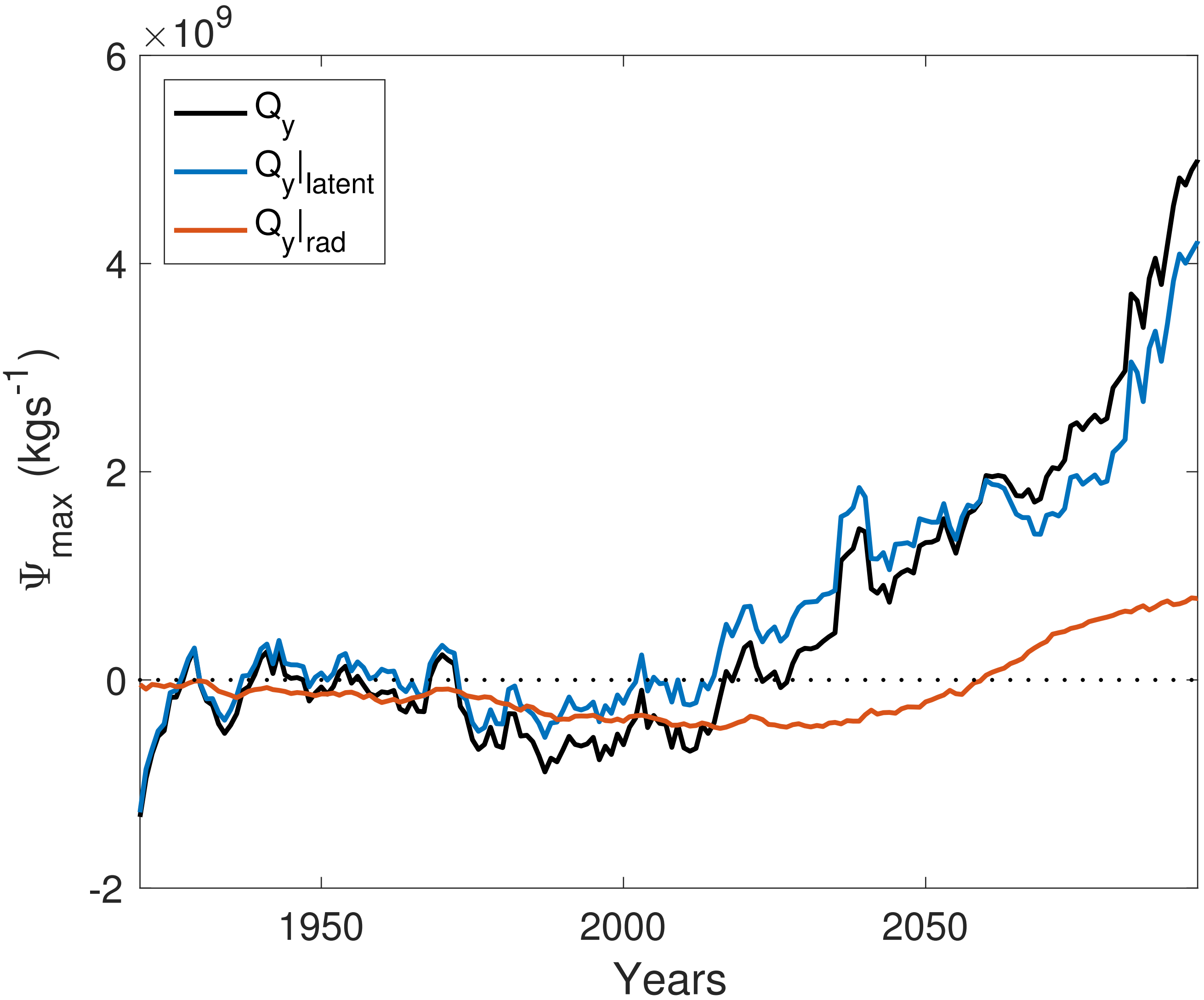

Figure S3. The relative contributions to changes in Ψ^{KE}_{max} under the historical and RCP8.5 forcing in CESM LE from diabatic heating (Q_y, black), and from decomposing Q_y to latent ($Q_y|_{latent}$, blue) and radiative heating ($Q_y|_{latent}$, red)