Symmetric and antisymmetric components of polar-amplified warming

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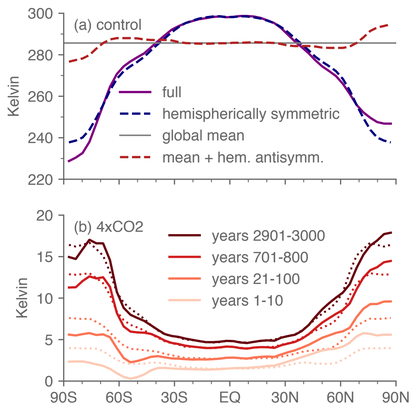
I. CO2-induced warming starts strongly antisymmetric about the equator and then becomes increasingly symmetric

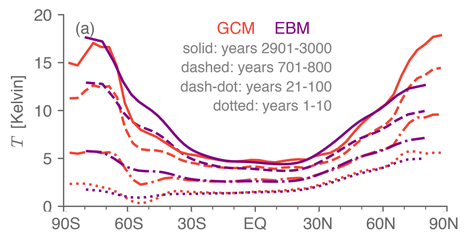


Zonal-mean surface air temperature (*T*), low-res CESM1.0.4

Symmetric component = avg. of given latitude in both hemispheres
Antisymmetric = Full minus symmetric

CO2 warming, initial decades: rapid Arctic, suppressed Antarctic warming
S. Ocean upwelling slows warming

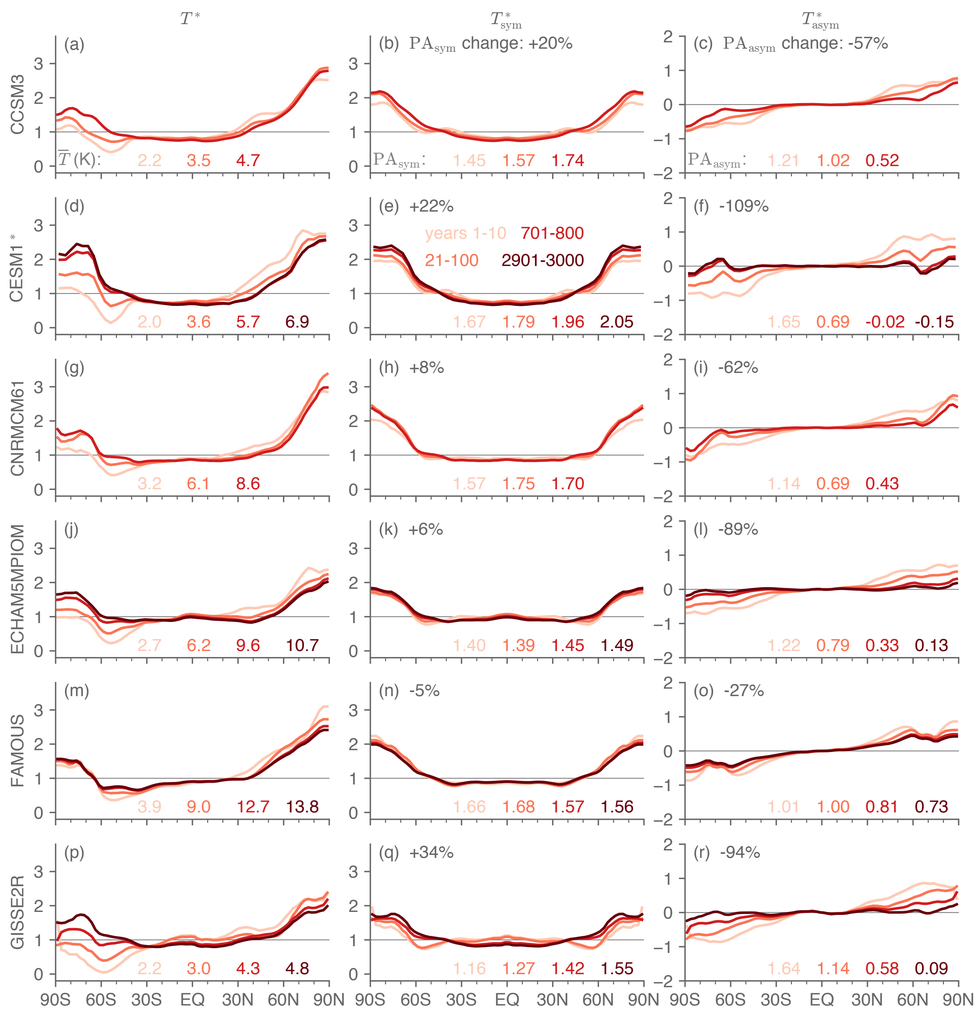
Antarctic catches up over subsequent centuries + millennia
All this is very well known



A moist energy balance model (MEBM) captures the salient behaviors from CESM1
Boundary forcings diagnosed from CESM1

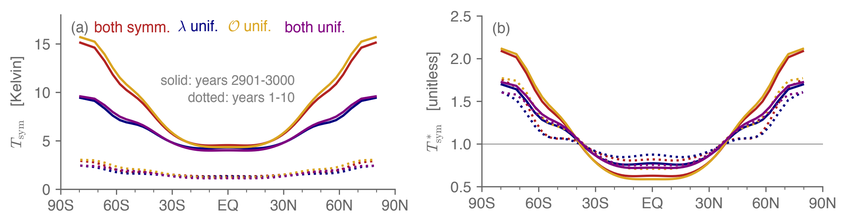
We find across 12 GCMs that the symmetric, mean-normalized warming pattern, T^*_{sym}, changes weakly from decadal to millennial timescales

II. In 12 LongRunMIP GCMs run 1000+ yr under 4xCO2, symmetric warming component changes little w/ time

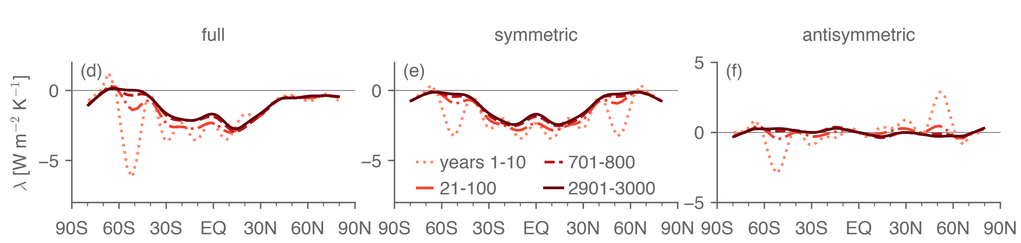


(left) full, (center) symmetric, and (right) antisymmetric mean-normalized warming in 6 of the 12 GCMs analyzed (others not shown for brevity but similar)

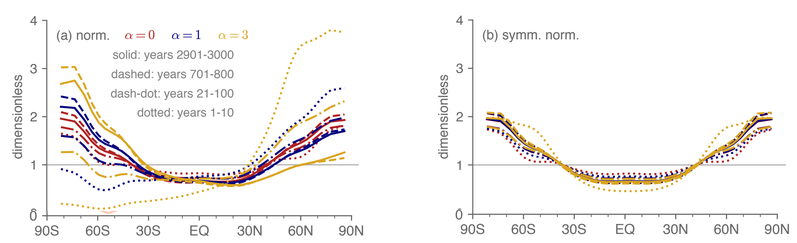
III. MEBM: due primarily to ~consistency of spatial pattern of radiative feedback parameter, λ_{sym}



I.e. T^*_{sym} unchanged to extent λ_{sym} pattern unchanged
Whereas making OHU uniform: much less impact

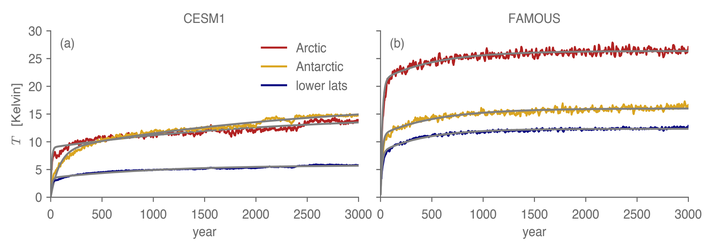


But λ becomes much less stabilizing over S. Ocean after first decade
Weakens λ_{sym} in high v. low latitudes: why P.A increases slightly w/ time



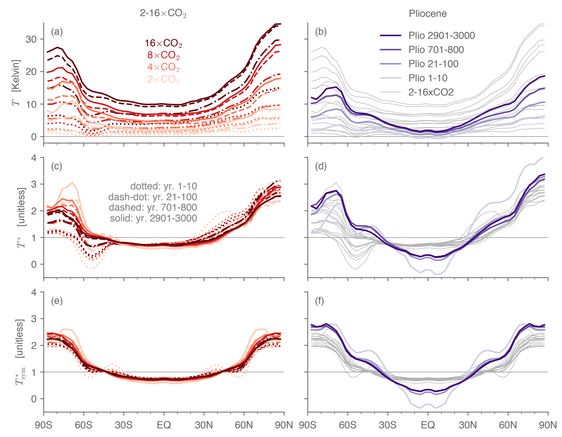
Re-ran the MEBM w/ the antisymmetric component of radiative feedback parameter and OHU artificially enhanced or removed
T^*_{sym} hardly changed! Antisymmetric and symmetric terms ~decoupled

IV. Fast/slow timescale box model fitted to end-member GCMs: key diff. is fast Antarctic timescale



C.f. Held et al 2010. Fast Antarctic timescale:
85 yr in CESM1 v. 15 yr in FAMOUS!
Why in FAMOUS antisymmetric component weakens much less in time

V. Consistency holds in CESM1 across 2-16xCO2 and (w/ distinct pattern) a Pliocene-like case



Ultimate motivation: holds for real Earth?
Where forcing isn't abrupt 4xCO2

CESM1 2-16xCO2 runs: same behaviors and pattern quasi-CO2 independent

Pliocene-like simulation in CESM1: distinct but likewise consistent T^*_{sym}

Useful next step: 1%/yr CO2 runs
Among many others we can discuss