

On the impact of instantaneous radiative forcing on tropospheric adjustment

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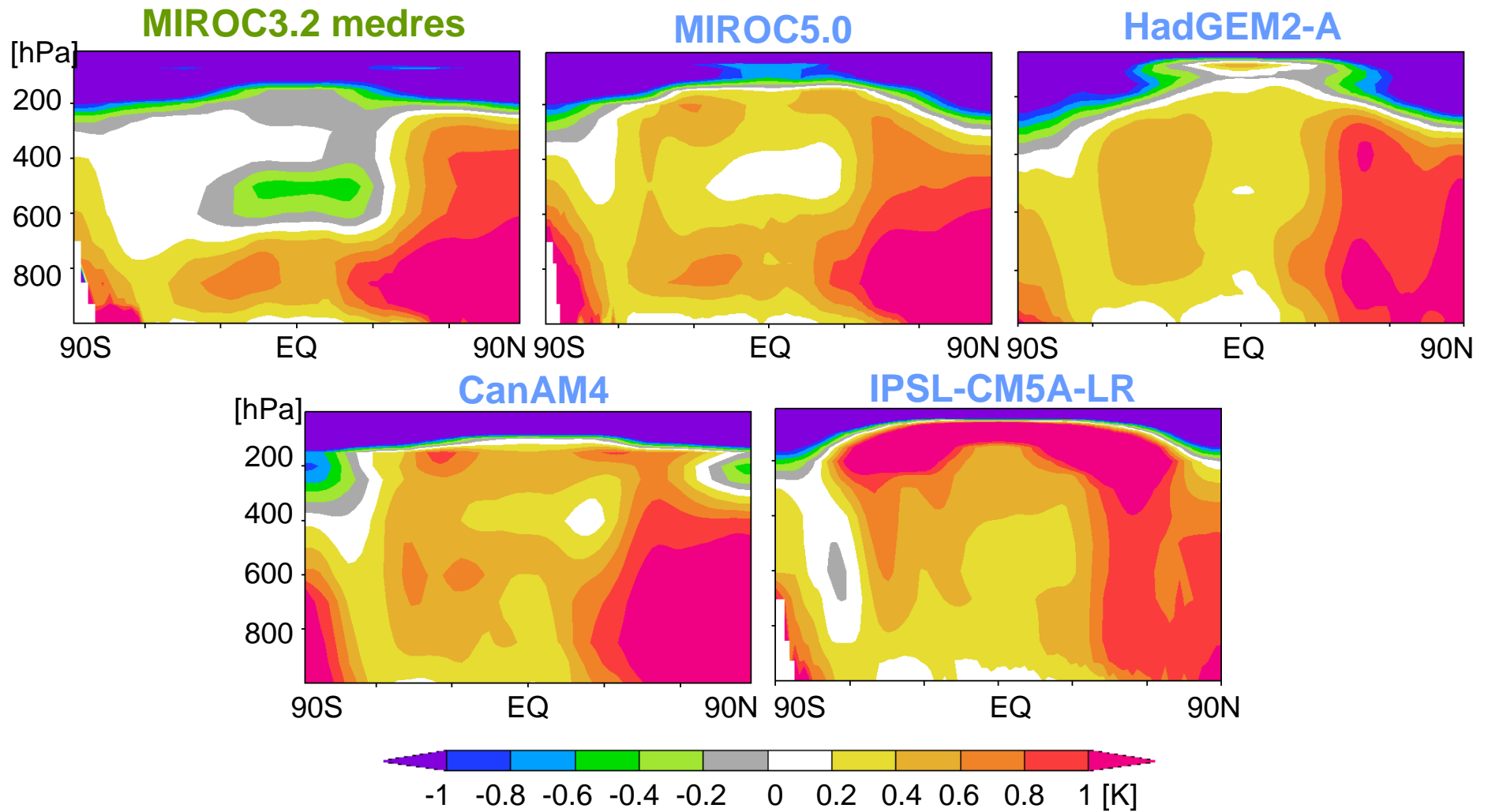
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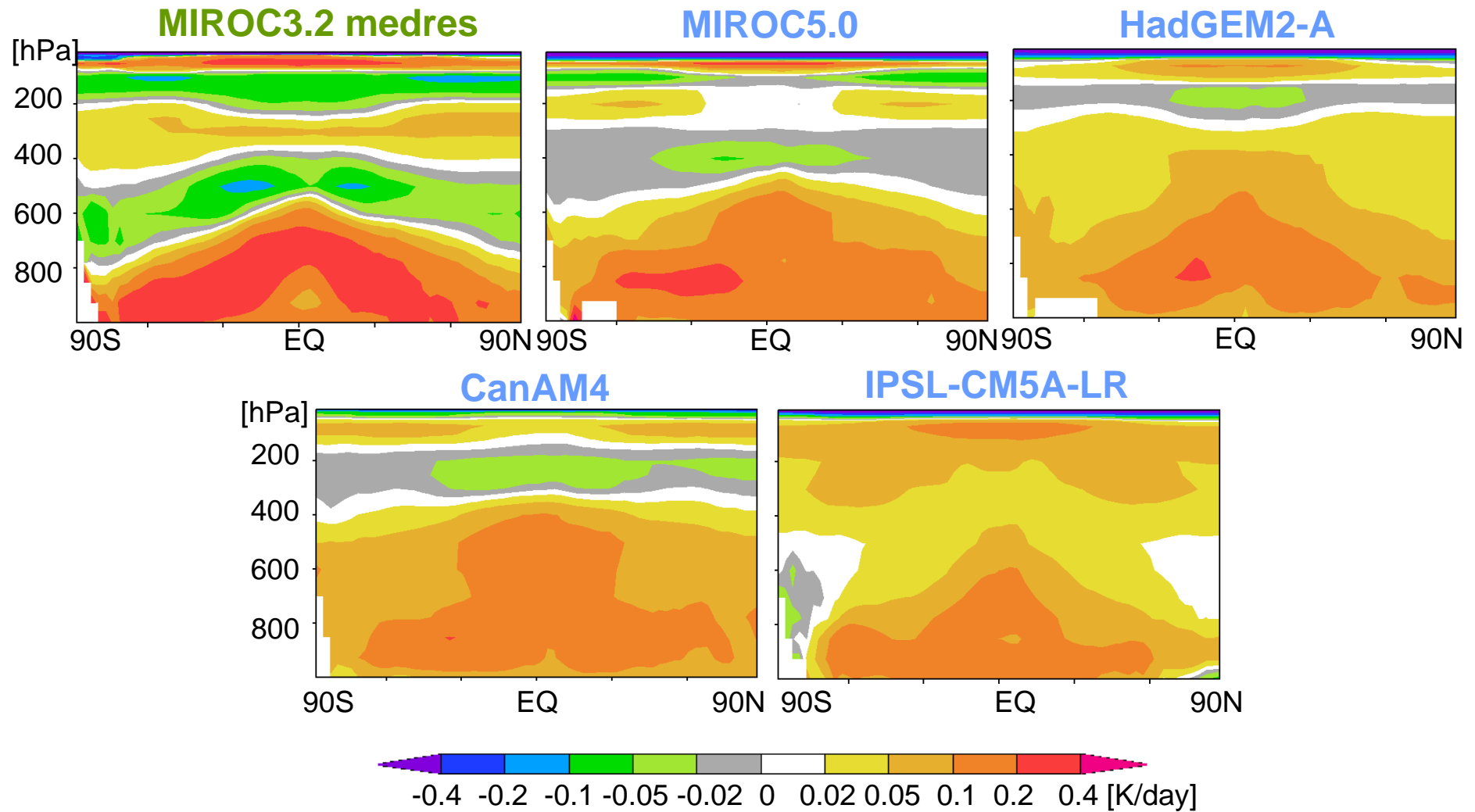
T response, AMIP4xCO2 - AMIP

(zonal annual mean, **CMIP3** / **CMIP5**)



Inter-model difference in T adjustment. It may be relevant to cloud adjustment.

Instantaneous Heating rate [K/day], CO2 quadrupling, AMIP (zonal annual mean, CMIP3 / CMIP5)



Heating rate may contribute to inter-model difference in T adjustment. To what extent ?

Prescribed heating experiment

- 1) Calculate inst. rad. heating of 4xCO₂ in AMIP run (5 models from CMIP3/5).
- 2) Prescribe the heatings to MIROC3.2 medres (T42 L20), as a boundary condition in AMIP run.

$$\frac{\partial T}{\partial t} = \underbrace{Dynamics. + Physics.}_{\text{Online}} + \underbrace{\text{Heating}}_{\text{Offline (boundary condition)}} \text{ [K/s]}$$

Model	Forcing
MIROC3.2	MIROC3.2
MIROC3.2	MIROC5.0
MIROC3.2	HadGEM2-A
MIROC3.2	CanAM4
MIROC3.2	IPSL-CM5A-LR

- 3) Run MIROC3.2 medres for 30 years to evaluate responses to different heatings.

Experiments

AMIP4xCO2 minus AMIP Model		Prescribed heating experiment Model / Forcing	
MIROC3.2	↑ Q1	MIROC3.2 / MIROC3.2	↑ Q2
MIROC5.0		MIROC3.2 / MIROC5.0	
HadGEM2-A		MIROC3.2 / HadGEM2-A	
CanAM4	↓ Q2	MIROC3.2 / CanAM4	↓ Q2
IPSL-CM5A-LR		MIROC3.2 / IPSL-CM5A-LR	

Issues to be discussed

Q1) Can the heating experiments emulate model response to CO2 quadrupling ?.

Q2) Can the heating experiments reproduce inter-model diff. in 4xCO2 responses ?

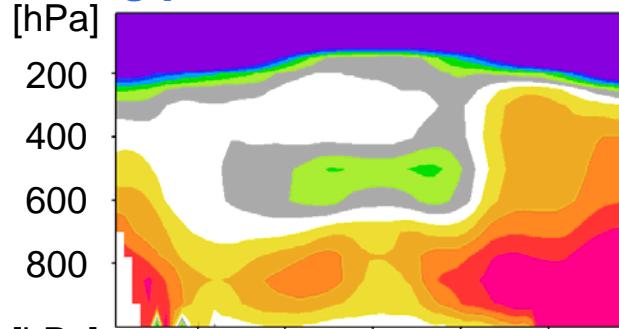
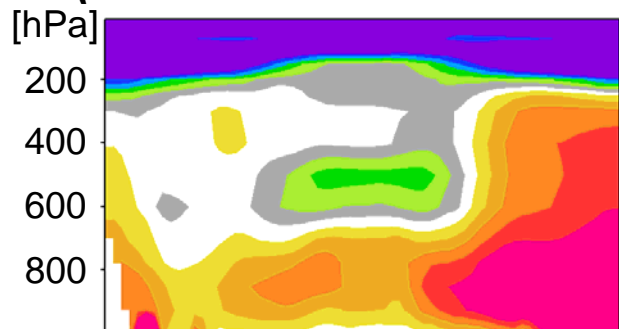
To illustrate the idea,

results from three models (MIROC3.2, MIROC5.0, HadGEM2-A) are shown first.

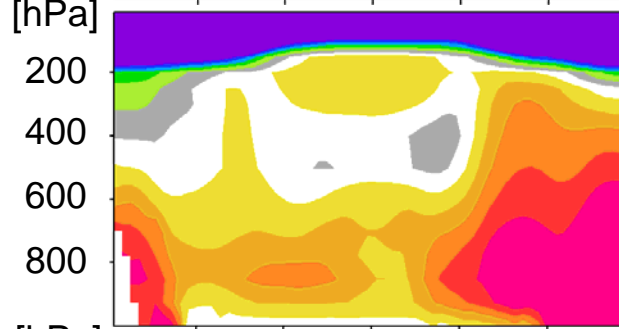
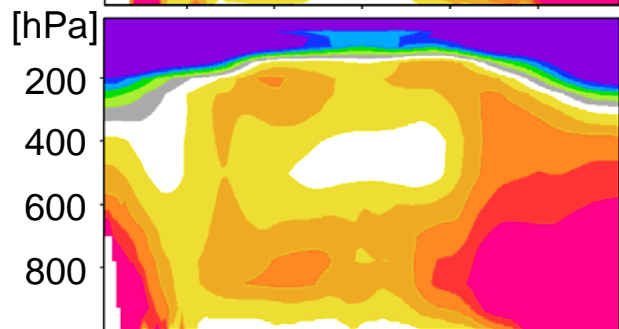
ΔT (AMIP4xCO₂ minus AMIP)

Heating prescribed to MIROC3.2

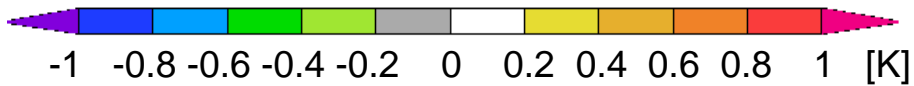
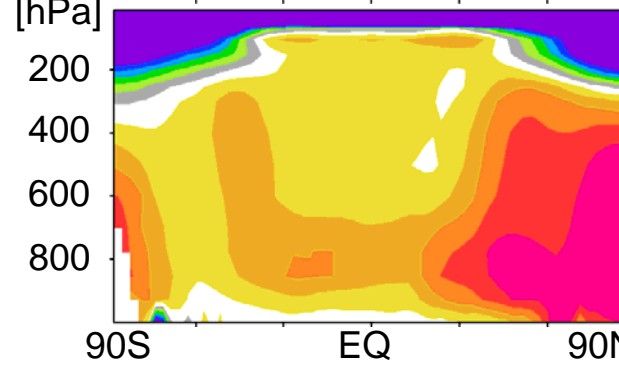
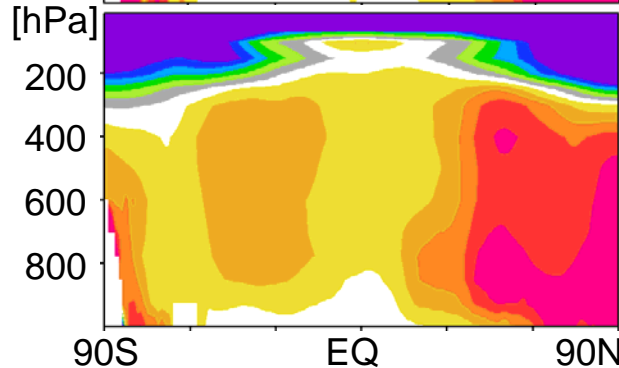
MIROC3.2



MIROC5.0



HadGEM2-A

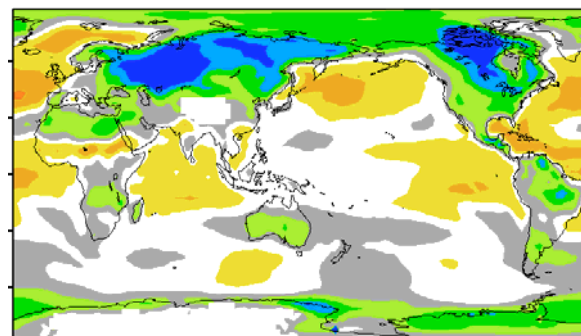
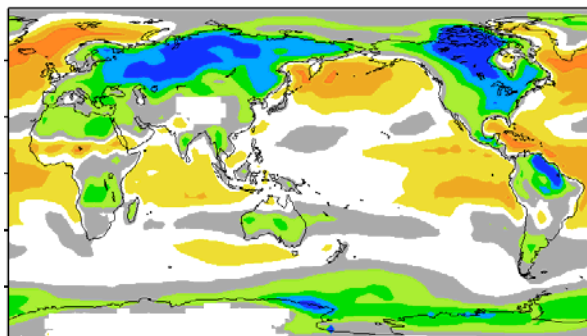


Inter-model difference in mid-troposphere reproduced w/ prescribed heating.

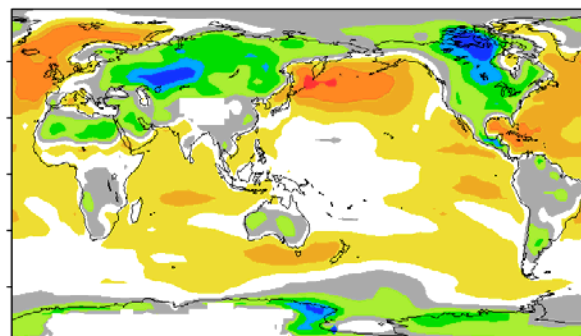
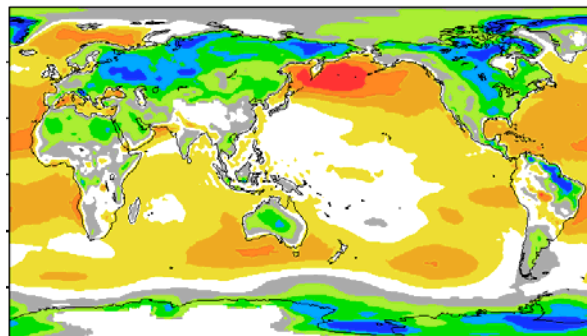
ΔLTS (AMIP4xCO2 minus AMIP)

Heating prescribed to MIROC3.2

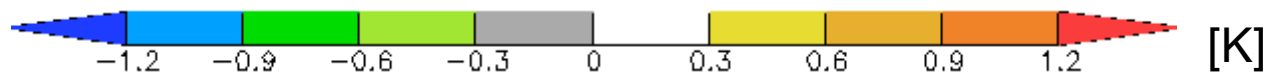
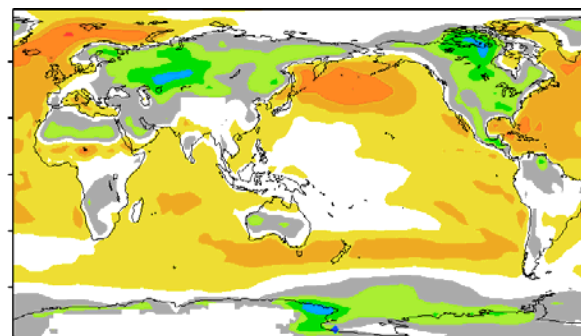
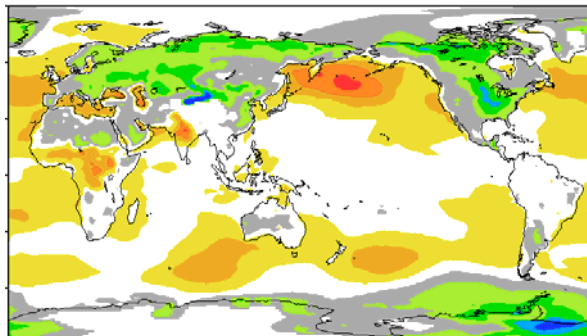
MIROC3.2



MIROC5.0



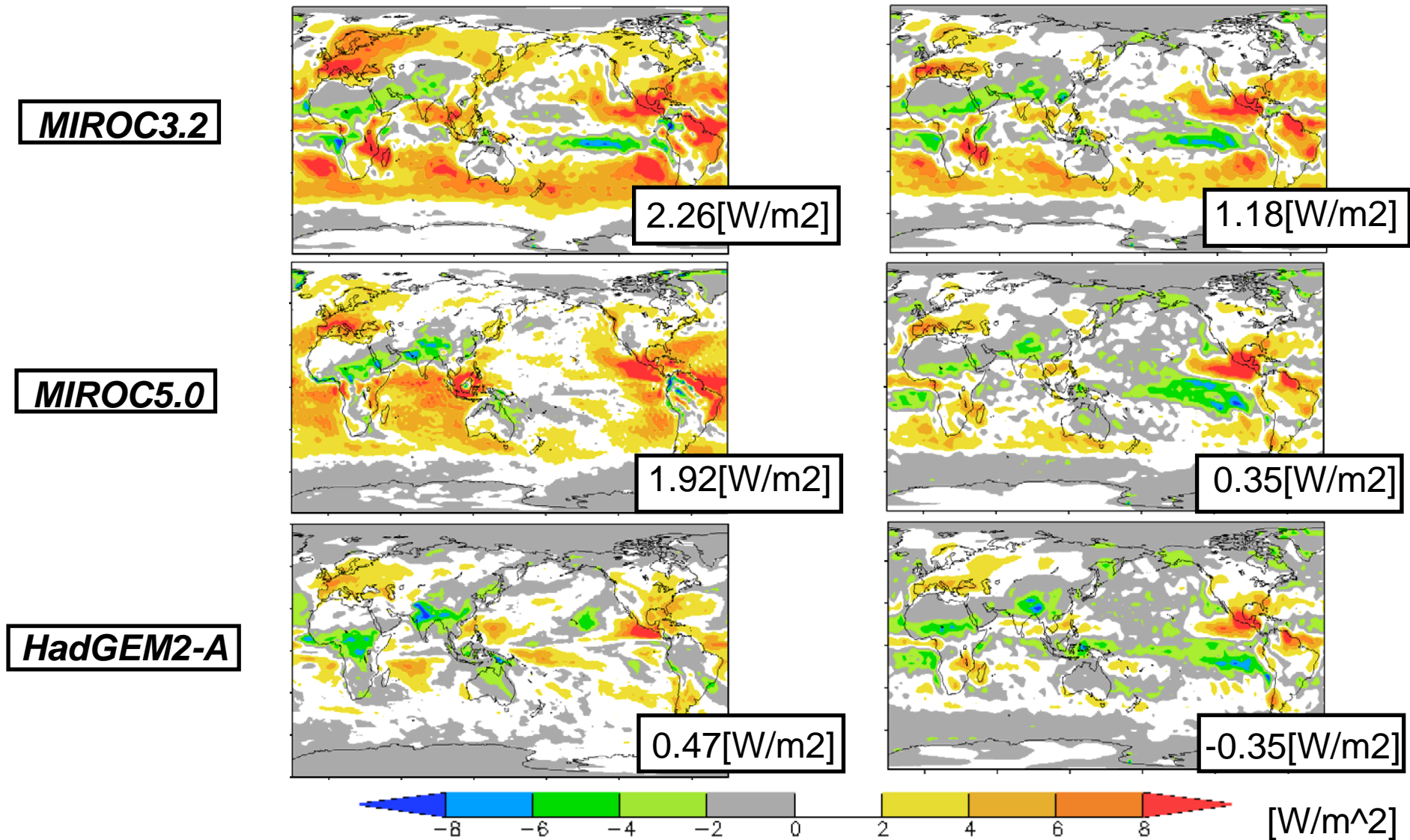
HadGEM2-A



Inter-model difference in subtropical ocean reproduced w/ prescribed heating.

Δ SCRE (AMIP4xCO2 minus AMIP)

Heating prescribed to MIROC3.2



Response to prescribed heating smaller than that to 4xCO2.

Inter-model difference in subtropical ocean reproduced w/ prescribed heating.

Discussion

Q1) Can the heating experiment emulate model response to CO₂ quadrupling ?.

→ Yes, to some extent.

But it tends to underestimate the response compared to 4xCO₂ runs.

x Prescribed heatings are monthly mean climatology.

x Cloud interact with radiation with 1xCO₂ condition.

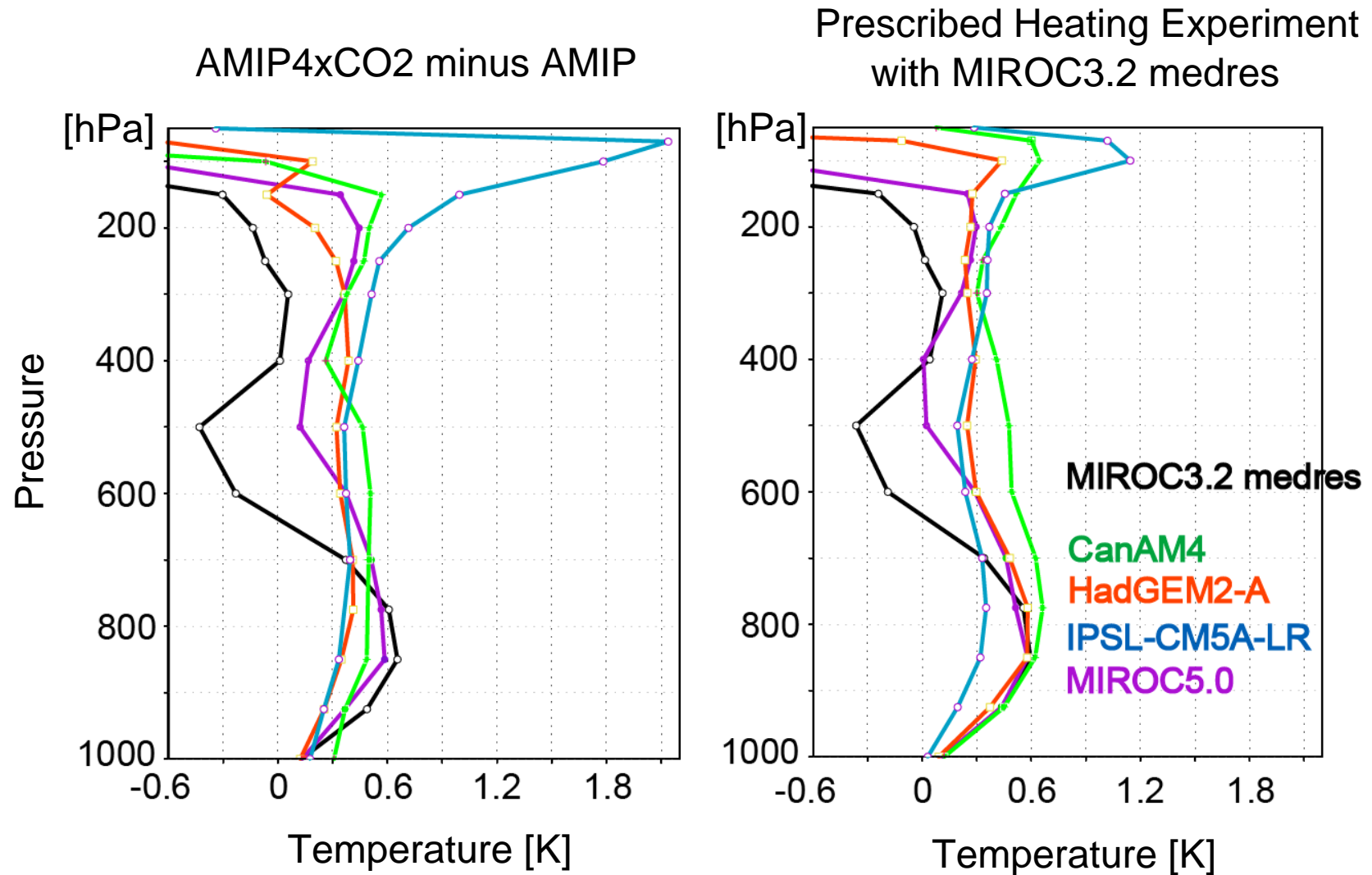
Q2) Can the heating experiments reproduce inter-model diff. in 4xCO₂ responses ?

→ Yes, to some extent.

Consistent with the idea that inst. rad. heating contributes to the inter-model spread in T, LTS, and SCRE adjustments.

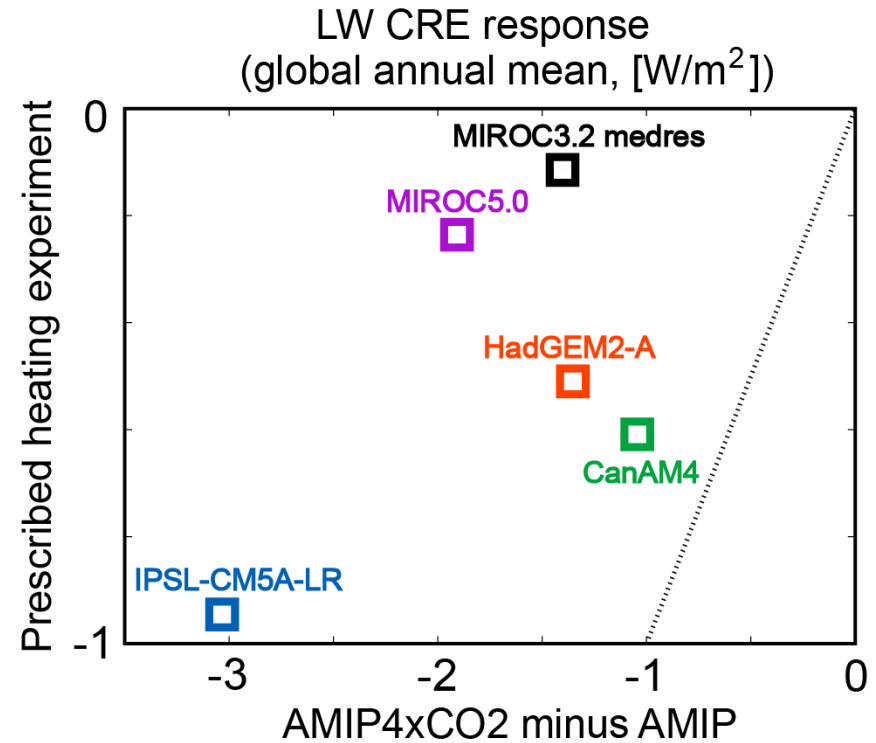
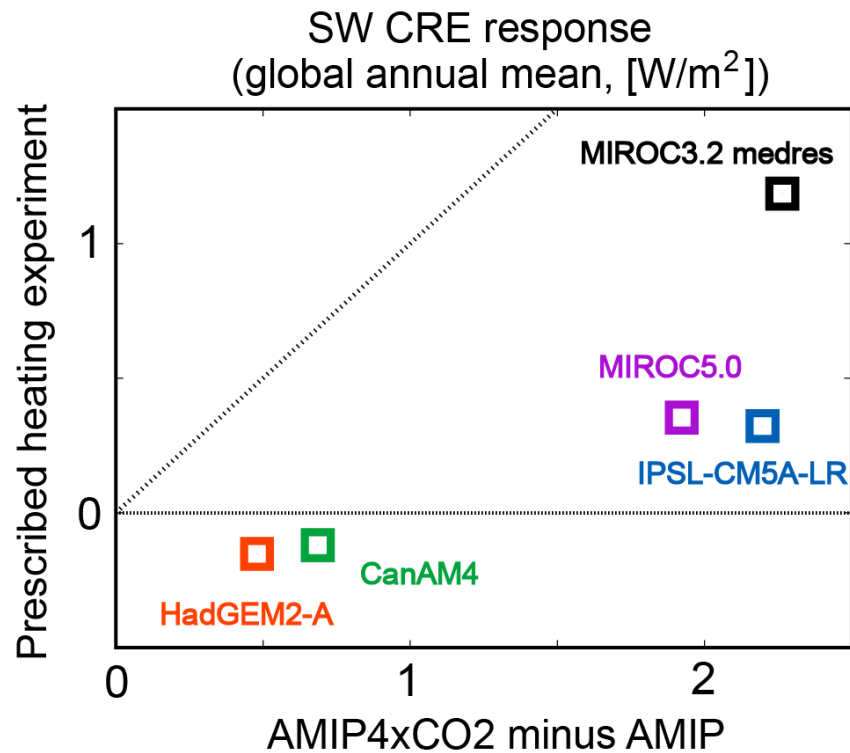
To see the robustness of above argument, results of 5 CMIP3/5 models are shown next.
(Note: result of IPSL-CM5A-LR heating is tentative. Only 18 years of run completed.)

T response (30S-30N average, annual mean)



Some of inter-model diff. in 4xCO2 reproduced by heating experiments.

Cloud Radiative Effect (CRE) response



SW: Inter-model diff. in 4xCO₂ responses related to heating responses (about 1.5W/m²).
LW: Relation bet. 4xCO₂ responses and heating responses not clear.

Summary

1. Prescribed heating experiment proposed for understanding inter-model difference in tropospheric adjustment induced by instantaneous radiative heating.
2. To illustrate the idea, preliminary results presented, where heatings of 5 models from CMIP3/5 given to MIROC3.2 medres.
3. Prescribed heating runs could successfully reproduce the adjustment in MIROC3.2, but quantitatively tend to underestimate the response (especially SW CRE).
4. Instantaneous radiative heating suggested as a contributing factor to the inter-model spread in T and SCRE adjustments in CMIP5.