Upper tropospheric Warming Intensifies Sea Surface Warming

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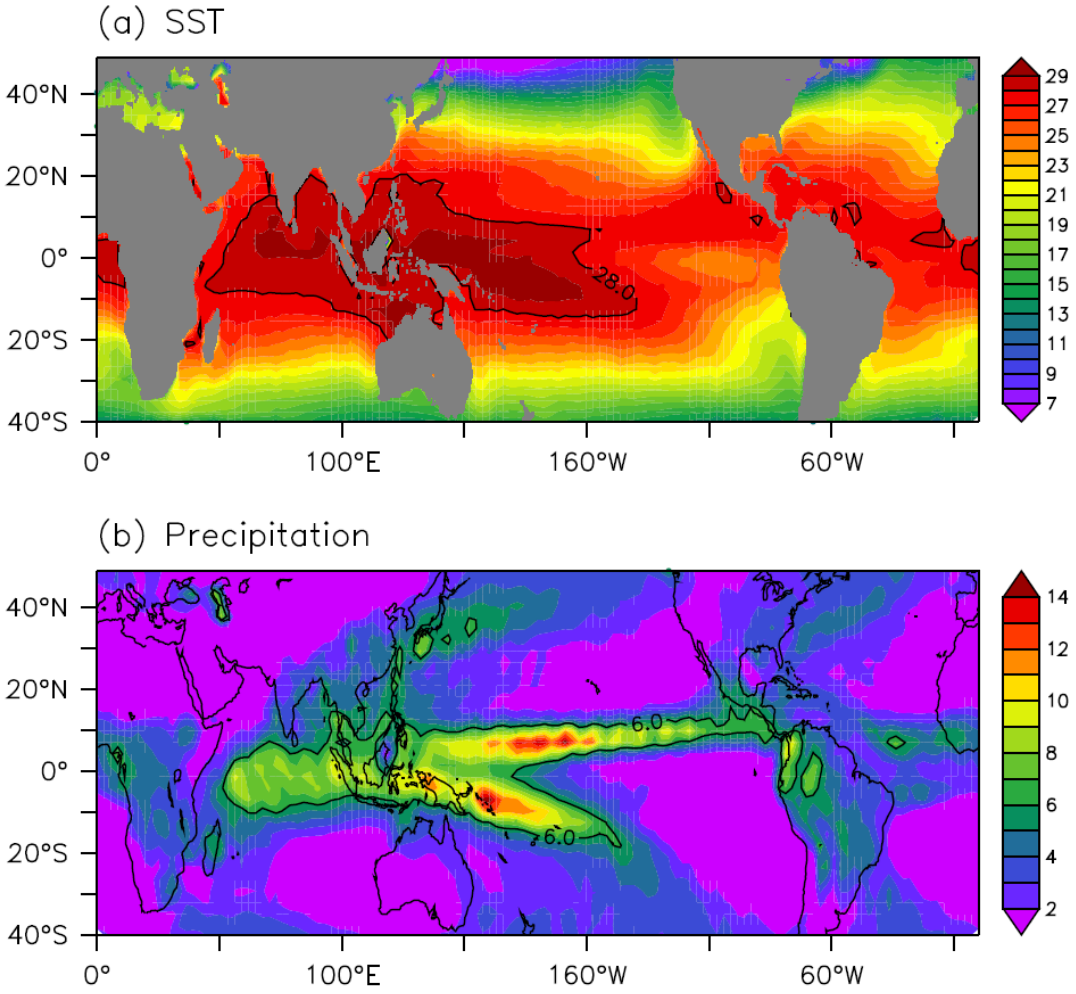
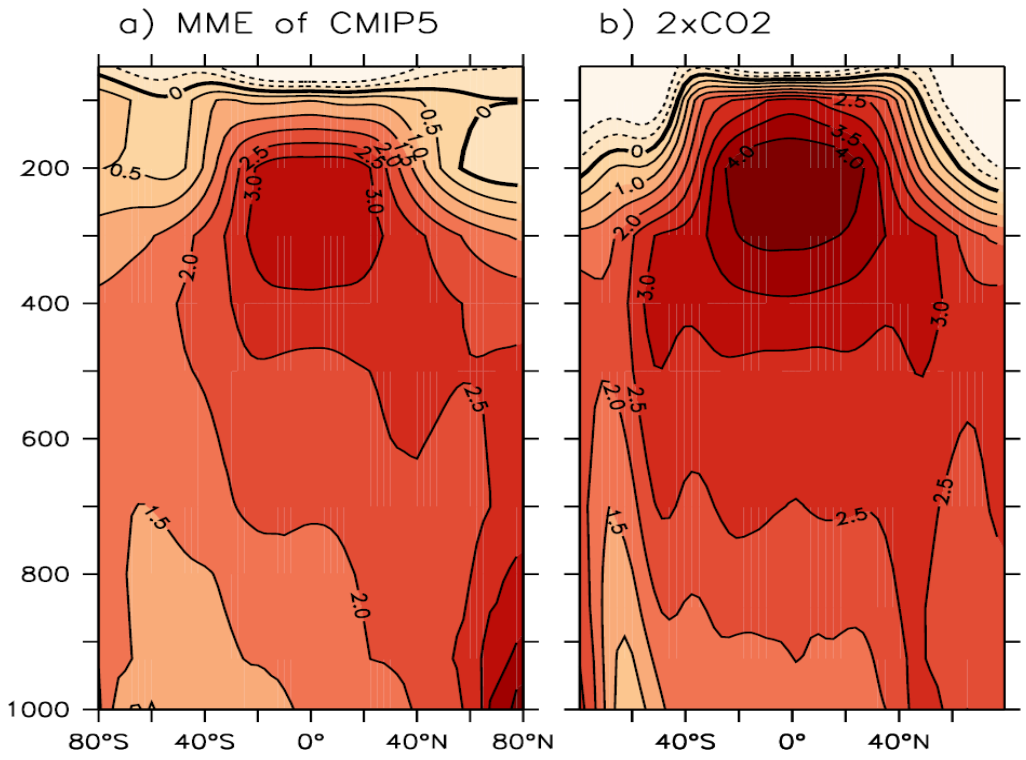
AGCM: ECHAM (v4.6)

CGCM: POEM (POP-OASIS-ECHAM Model) (Xiang et al.2012)



Background and Motivation



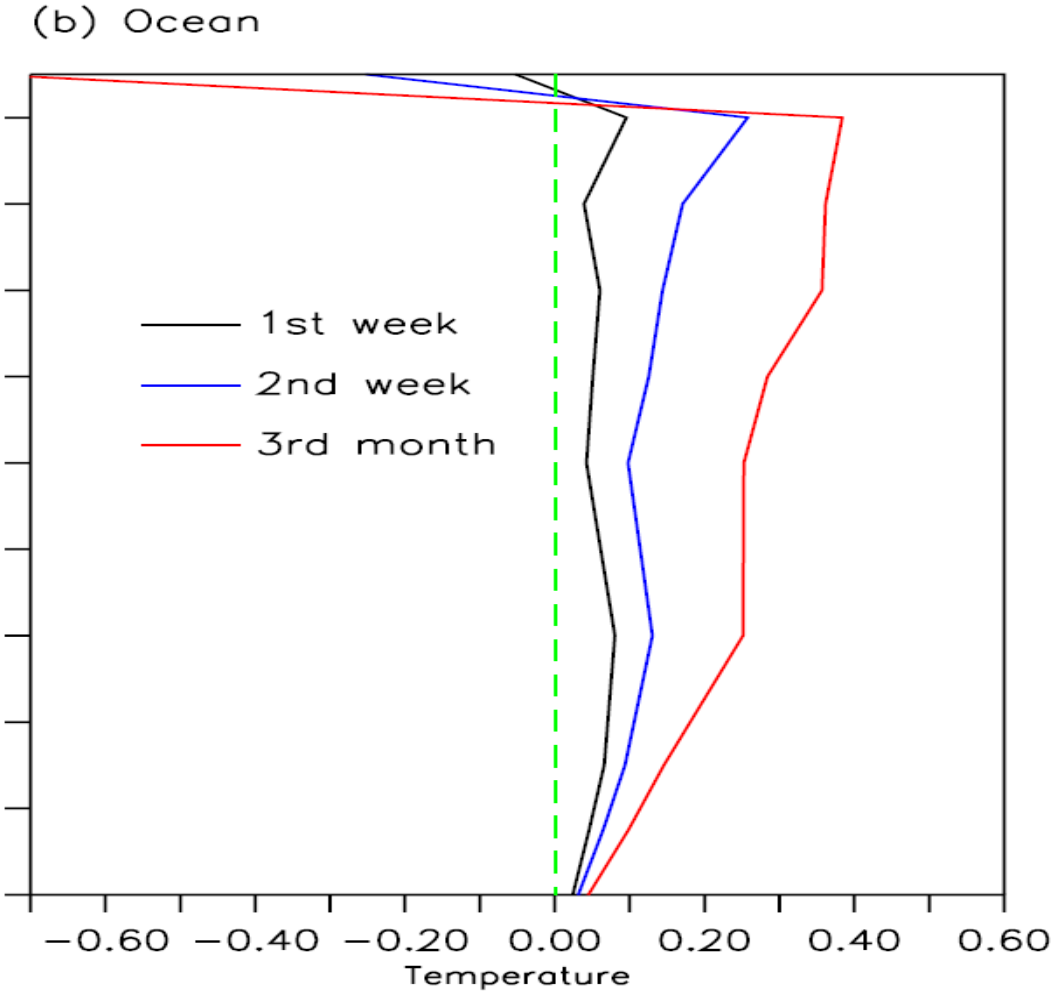
CMIP5 **POEM**

Future projection of vertical temperature changes

Transient temperature response to doubling CO2

--AGCM

Tropical Ocean
30S-30N

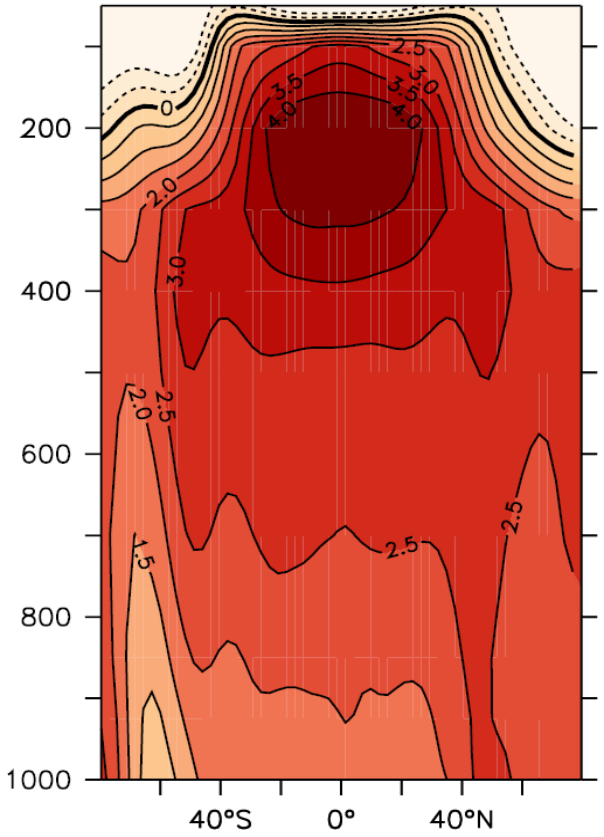


Question

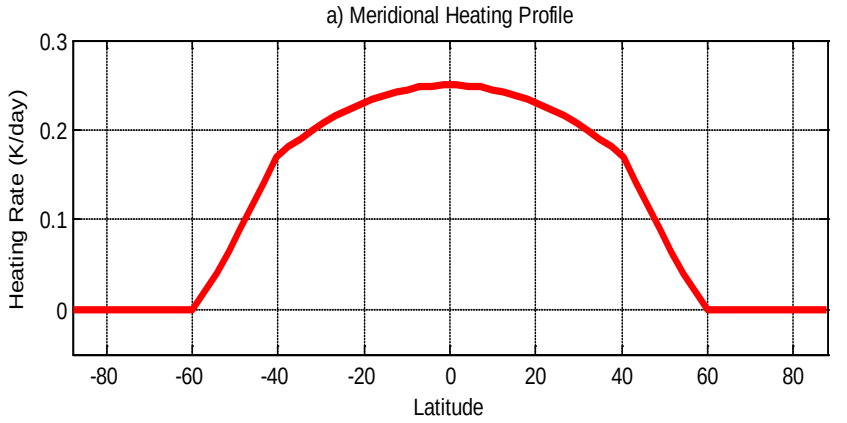
Whether the upper-tropospheric warming (**UTW**) can feed back to influence sea surface temperature?

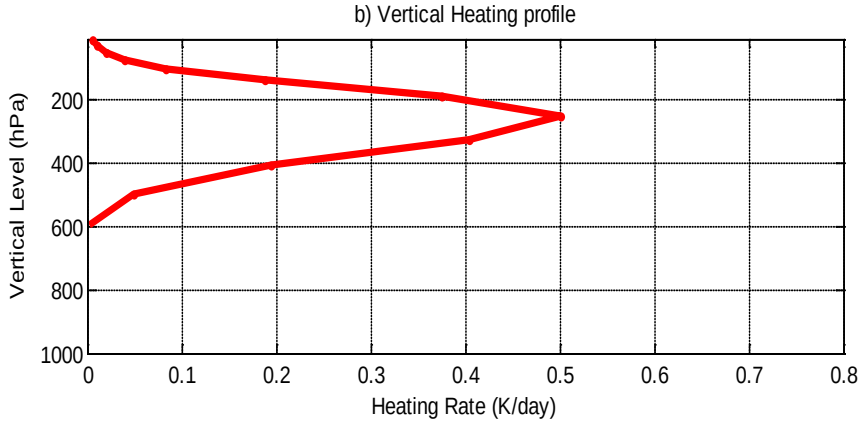
Tropospheric Heating Experiment

Temperature (2xCO2)

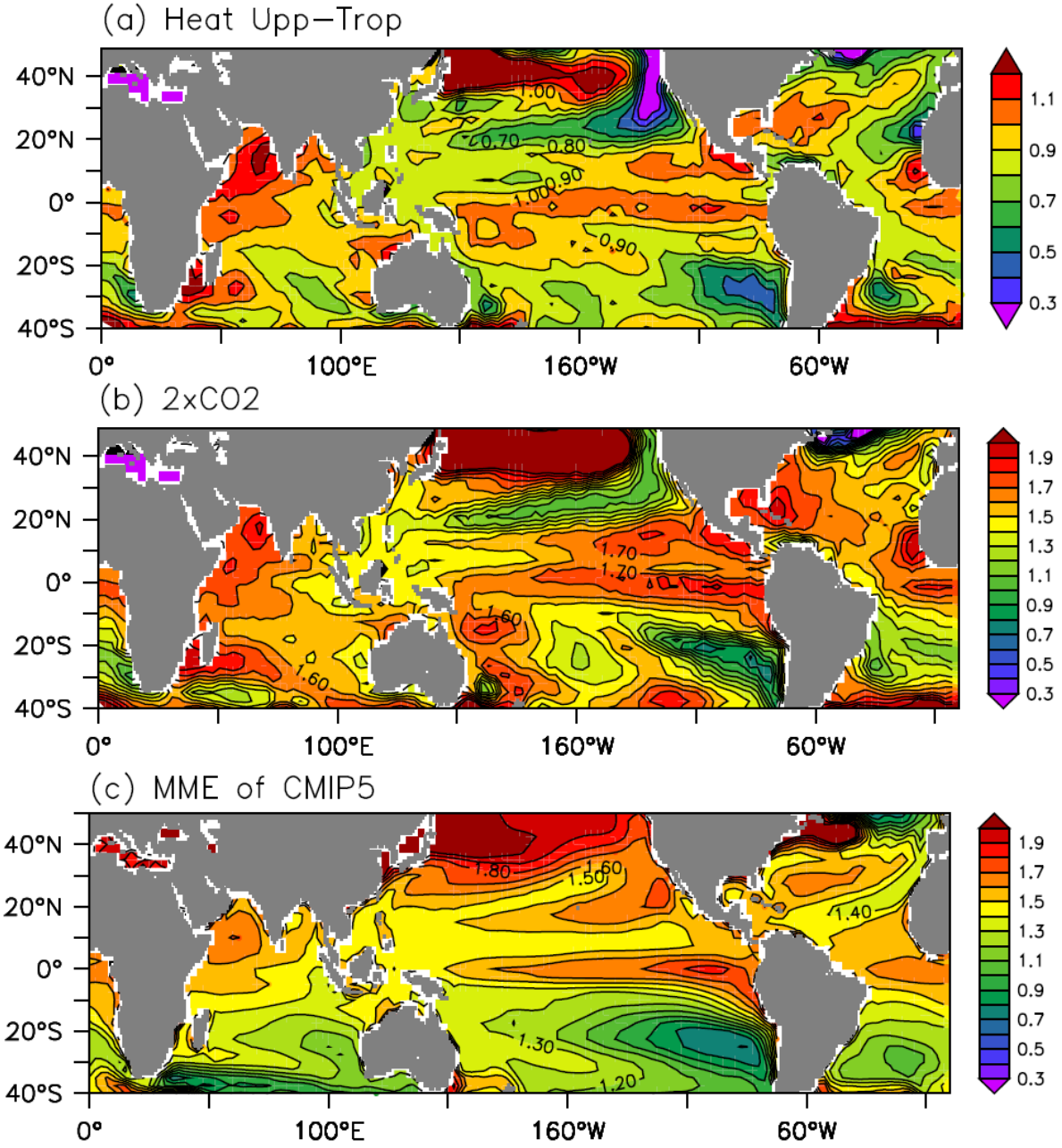


Heating Profile





SST change


(a) Heat Upp−Trop
40°N
20°N
0°
20°S
40°S
0°
100°E
160°W
60°W
1.00
0.70
0.80
0.90
1.00
0.90
1.1
0.9
0.7
0.5
0.3
(b) 2xCO2
1.70
1.20
1.60
1.60
1.9
1.7
1.5
1.3
1.1
0.9
0.7
0.5
0.3
(c) MME of CMIP5
1.80
1.60
1.50
1.40
1.30
1.20

Two Questions

1. What processes trigger the initial sea surface warming?

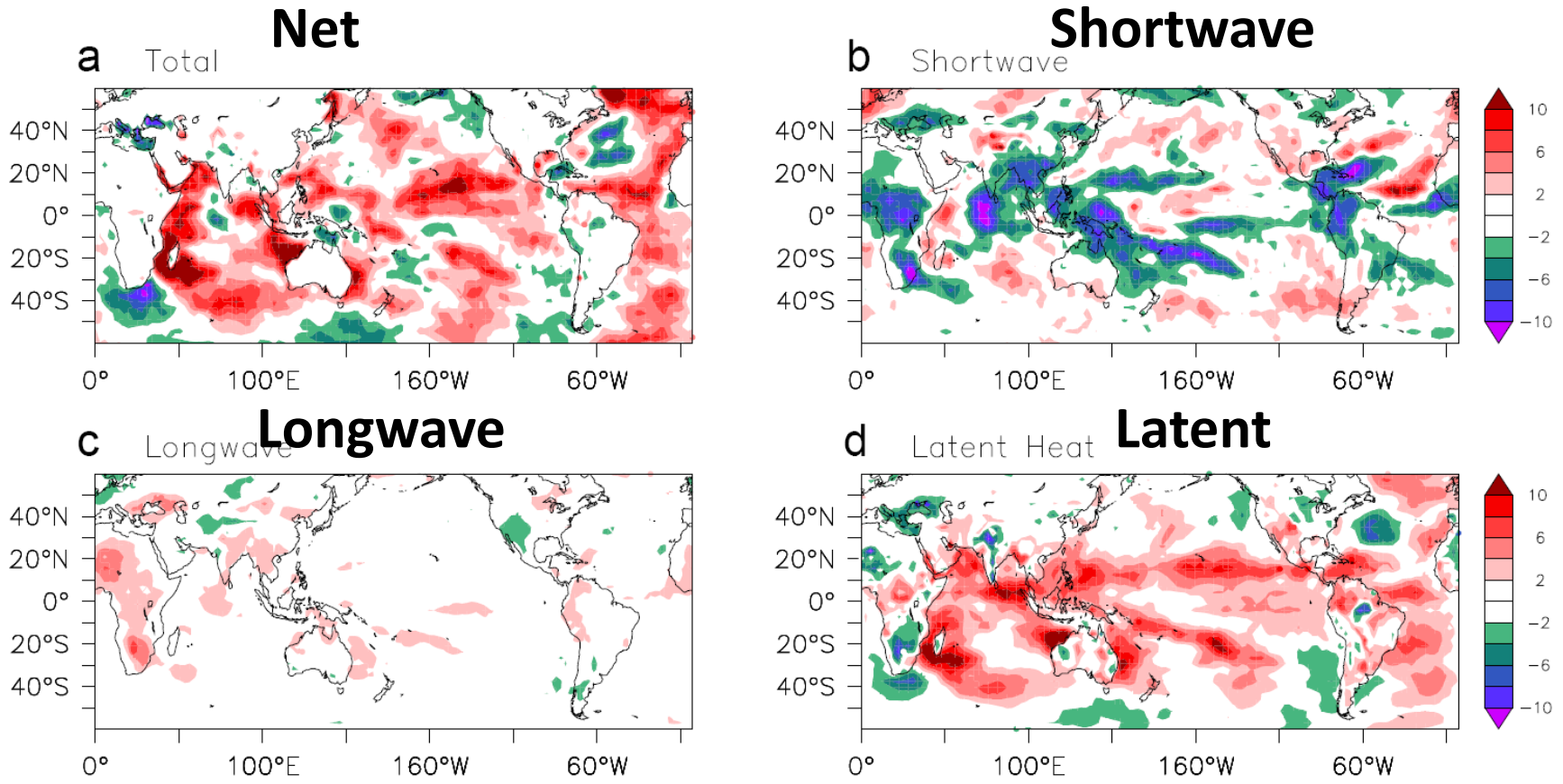
2. Do and if so how do the air-sea interactions and feedbacks regulate the initial surface warming?

Question I:

What processes trigger the initial sea surface warming?

-- Using AGCM

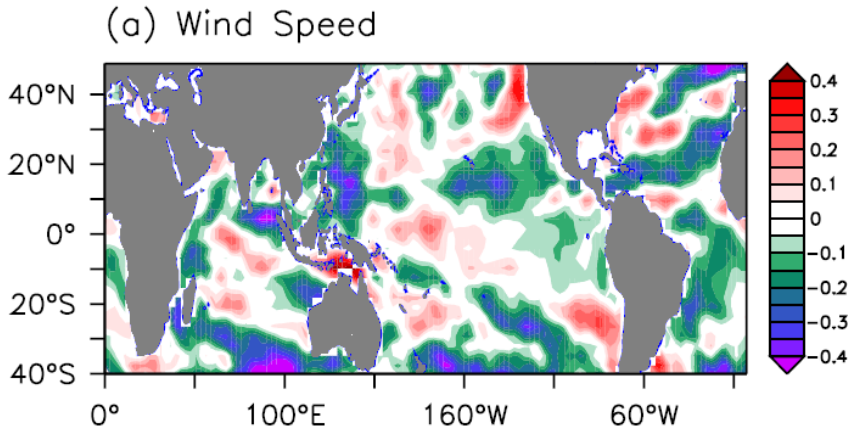
What triggers the initial warming?

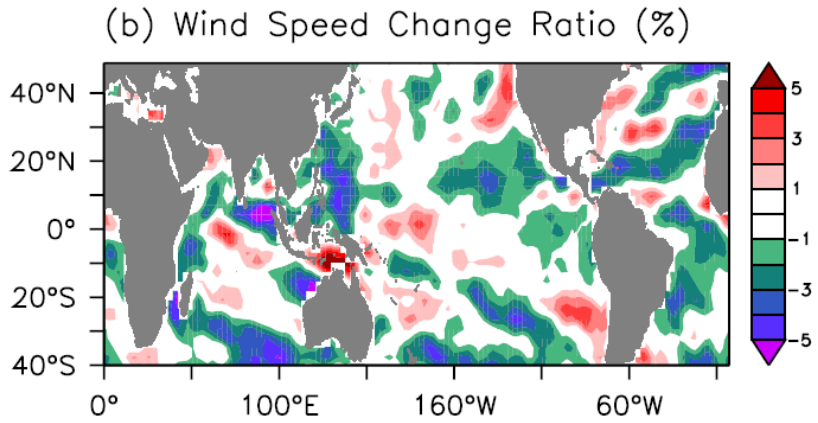


Reduced upward latent heat flux plays the dominant role

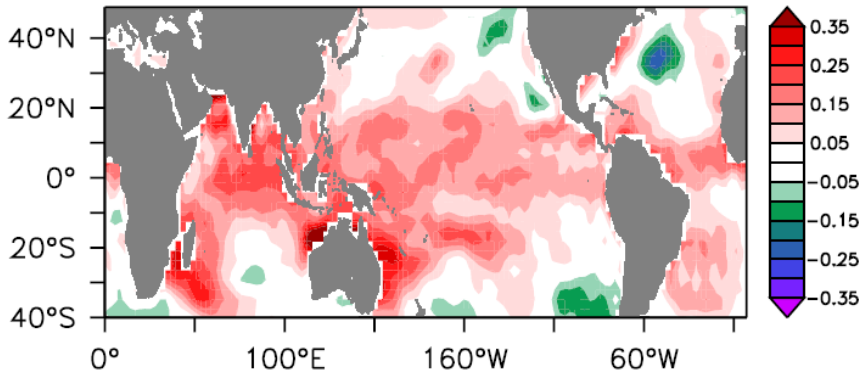
What induces less upward latent heat flux?

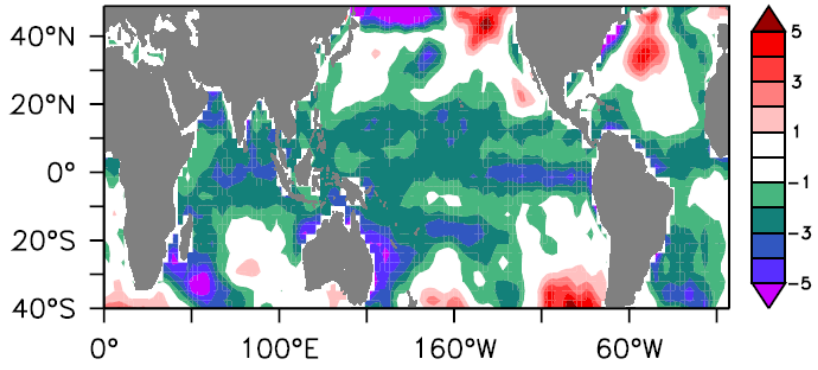
LHF=Lv C W (Qs-Qa)





-0.7%

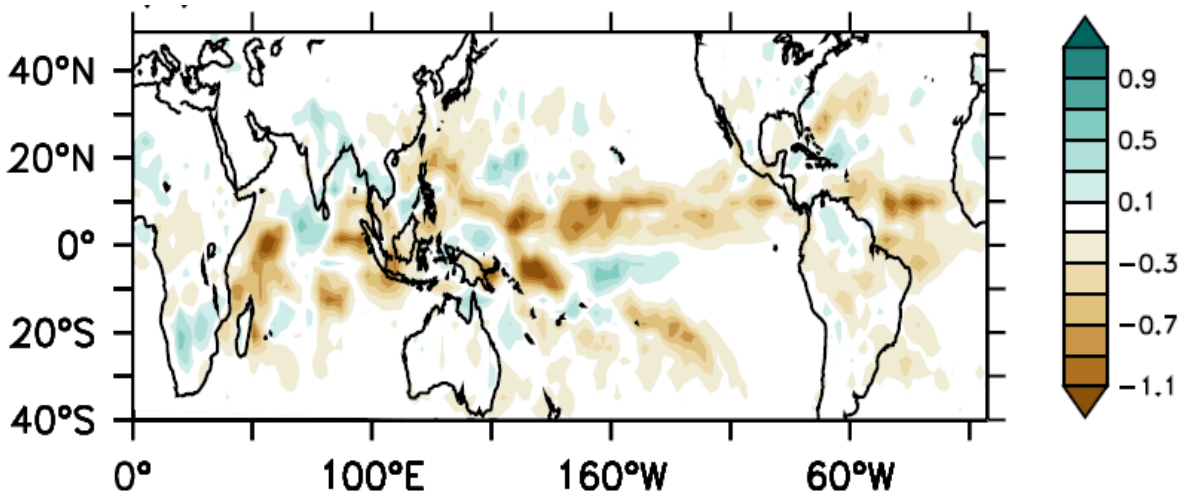




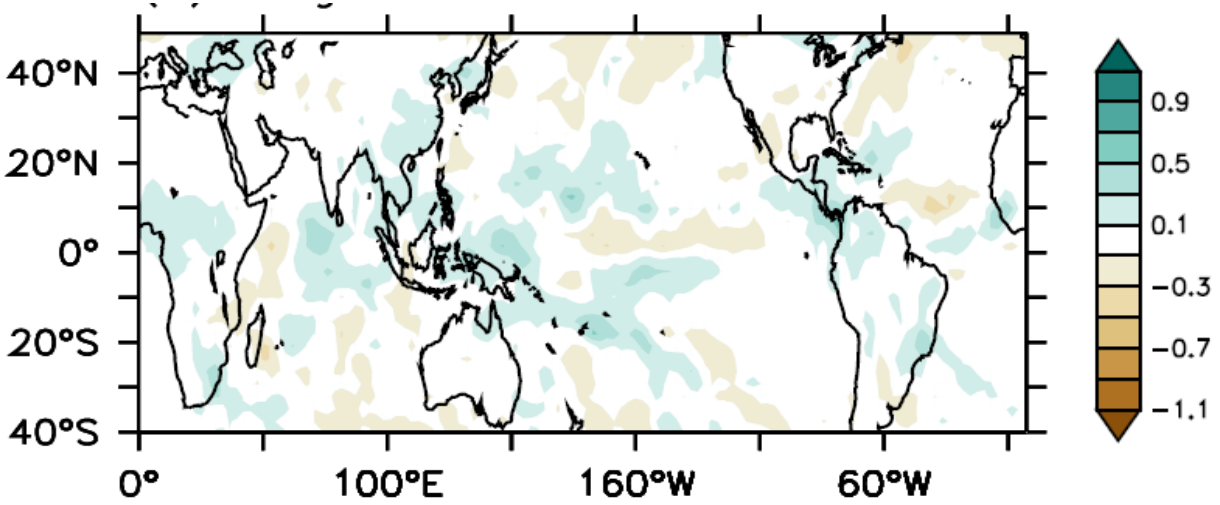
-1.8%

What results in more moisture near the surface?

Convective Precipitation



Large-scale Precipitation



1) What triggers the initial warming?

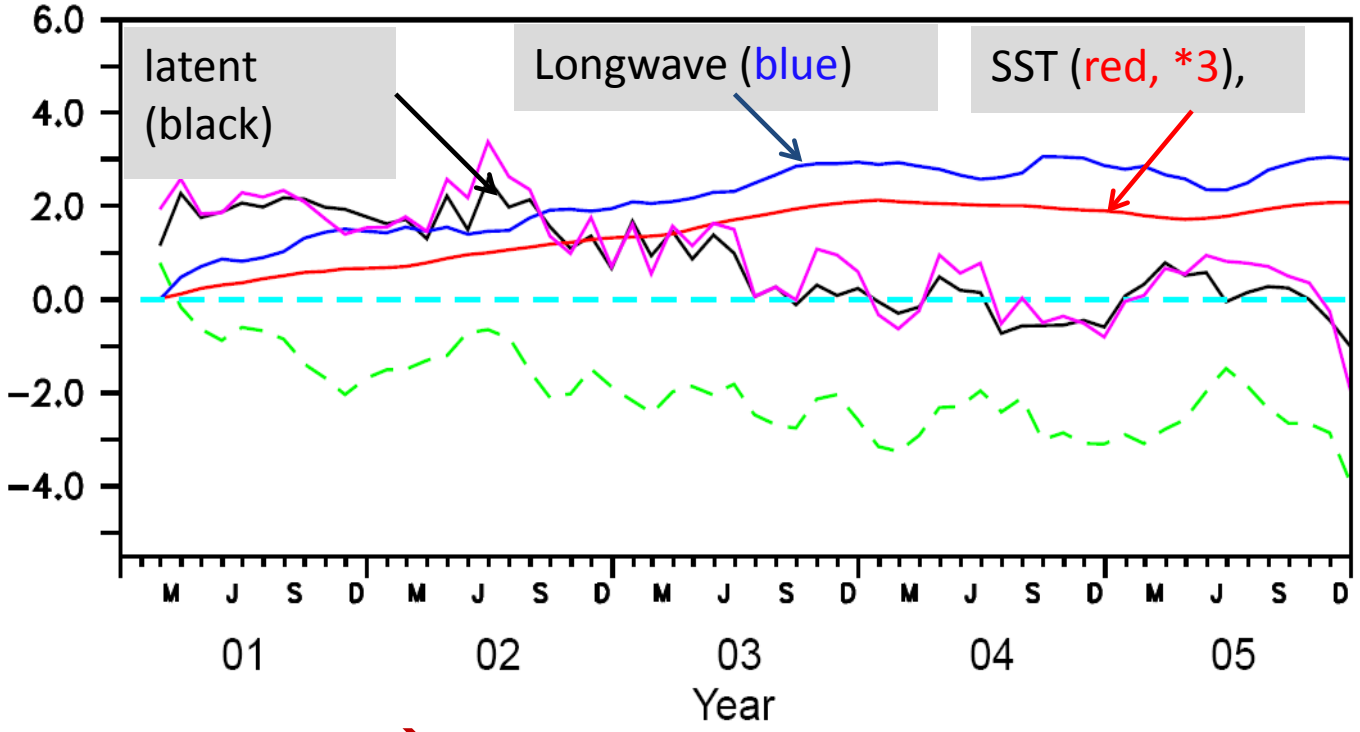
UTW →
Increased Atmospheric Stability →
Suppressed vertical moisture advection→
More moisture at lower troposphere →
Less upward latent heat flux →
Surface warming

Question II:

Do and if so how do the air-sea interactions and feedbacks regulate the initial surface warming?

-- Using CGCM

SST and heat flux evolution



UTW →

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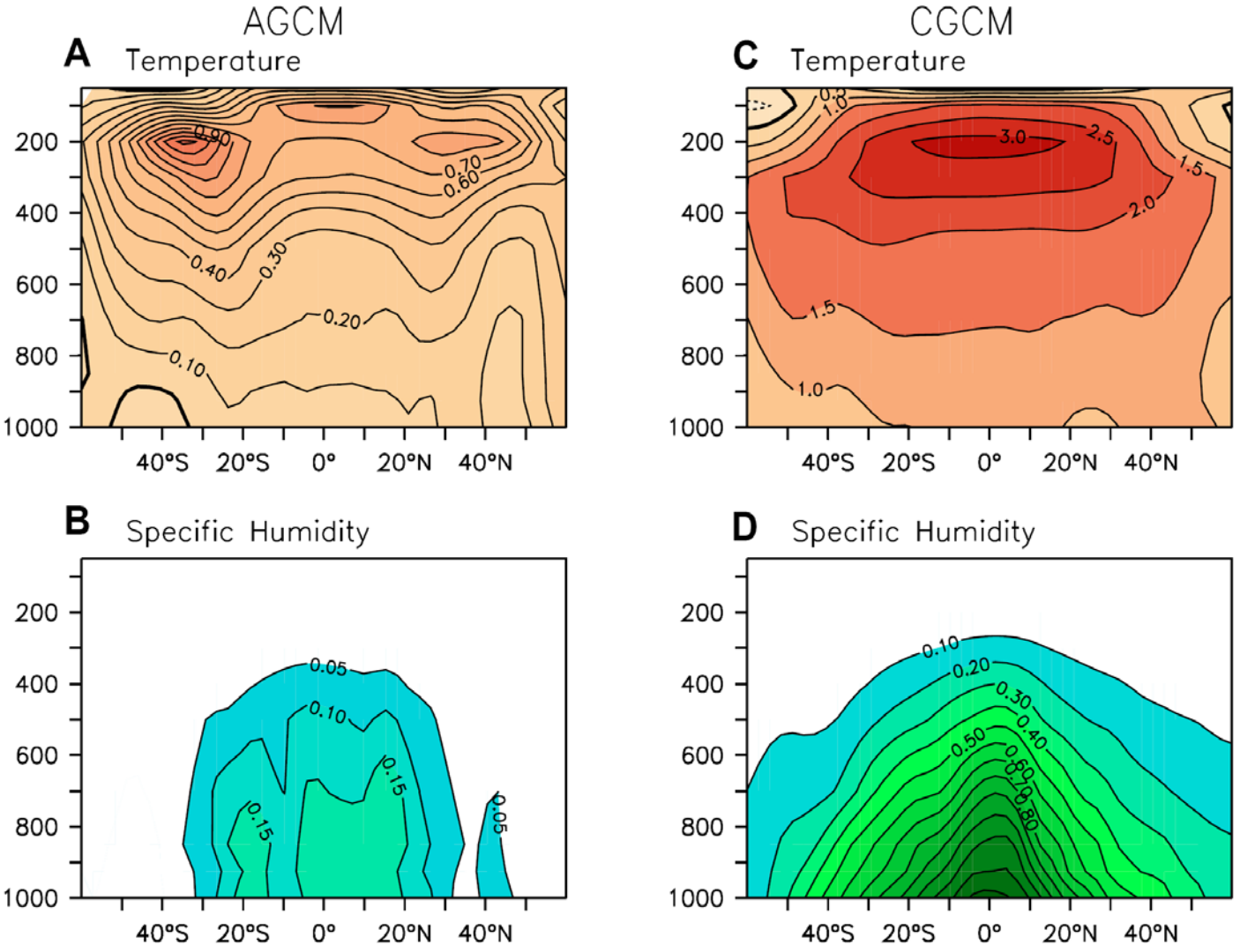
More moisture at lower troposphere →

1) Less upward latent heat flux →

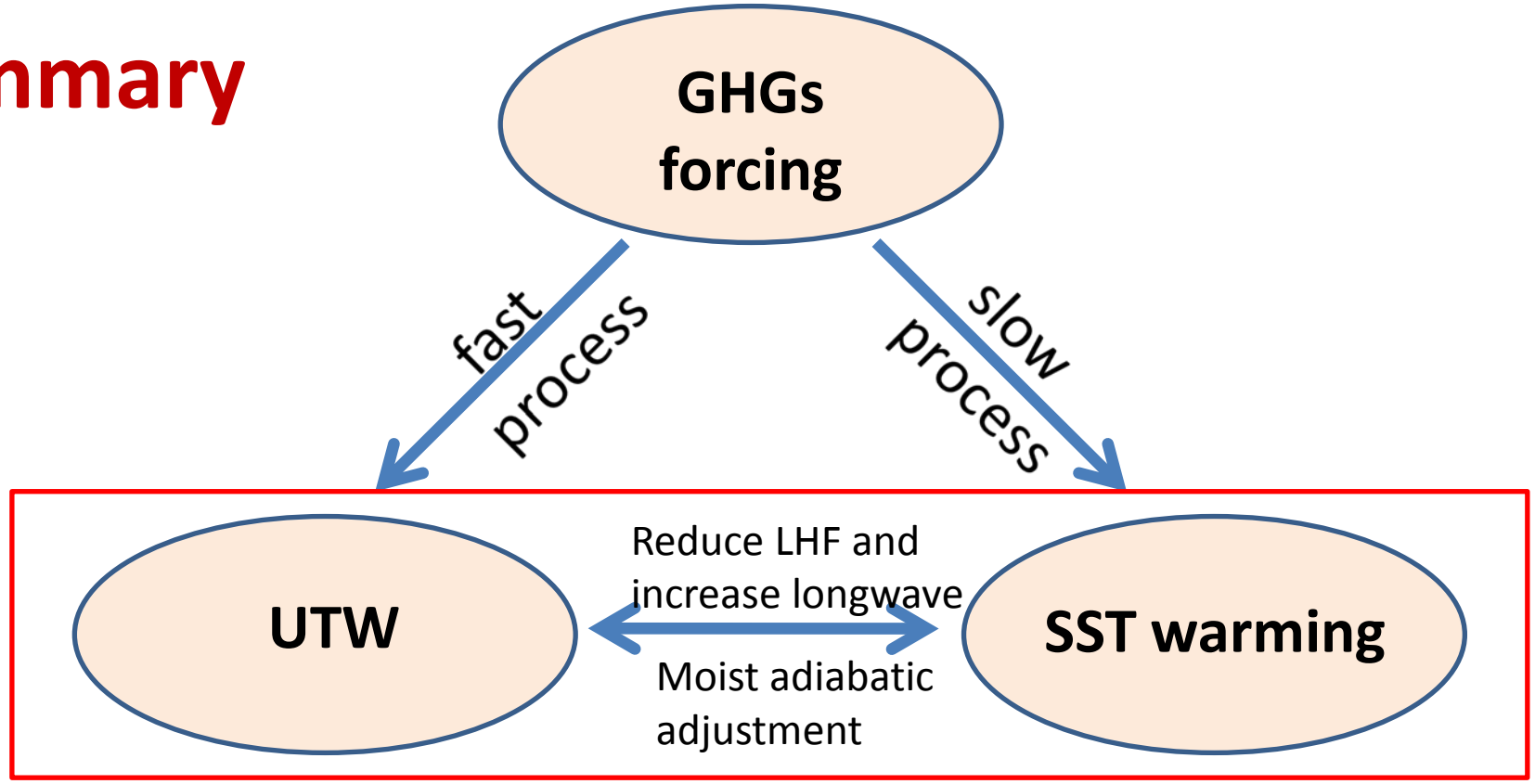
2) More longwave radiation →

Surface warming

Vertical Temperature and Specific Humidity



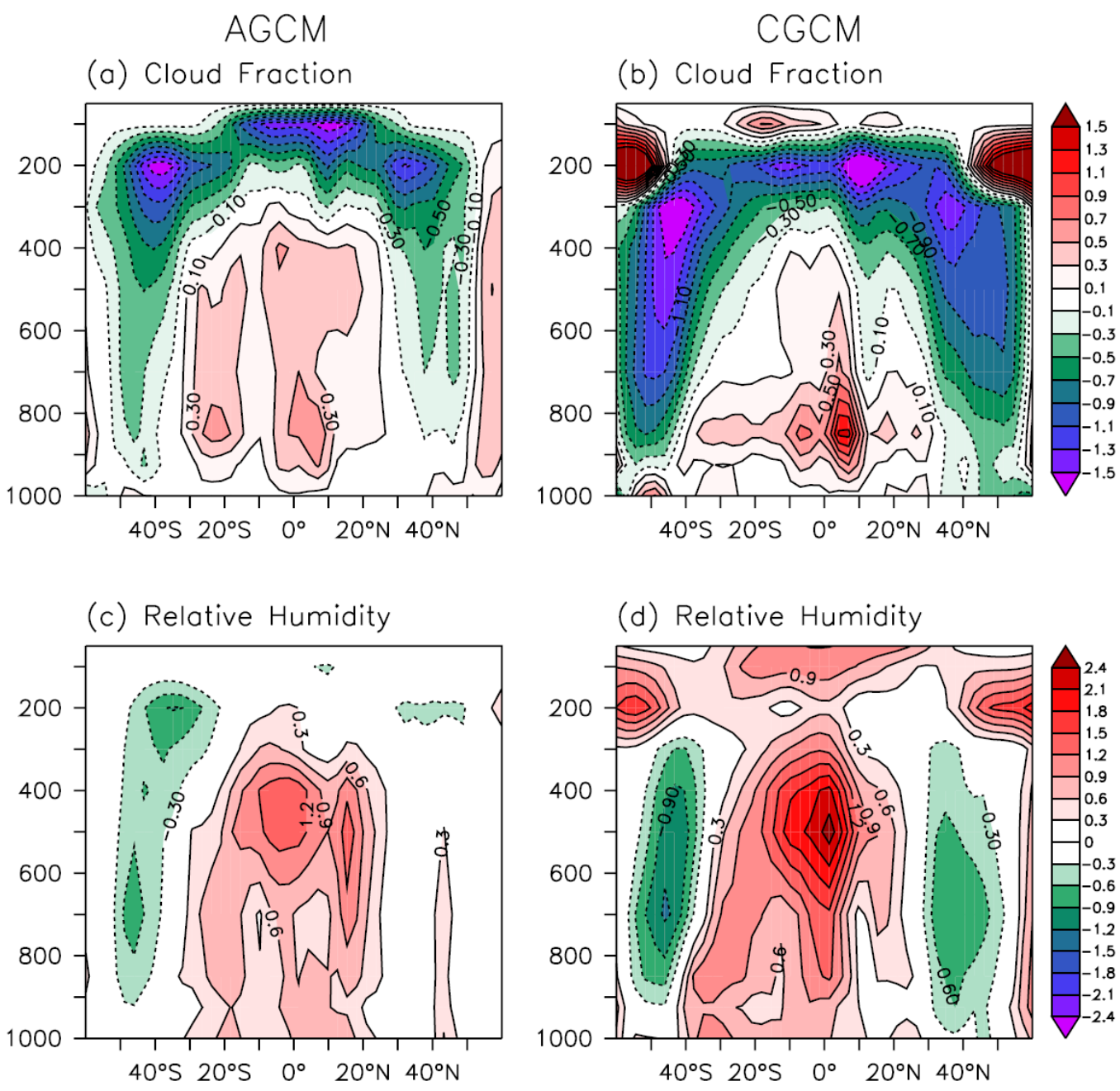
Summary



Conclusion:

1) Transient UTW can intensify surface warming via a **'top-down' mechanism**.
2) The UTW-induced SST warming can further strengthen the UTW due to the moist adiabatic adjustment so as to form **an UTW-SST positive feedback**.

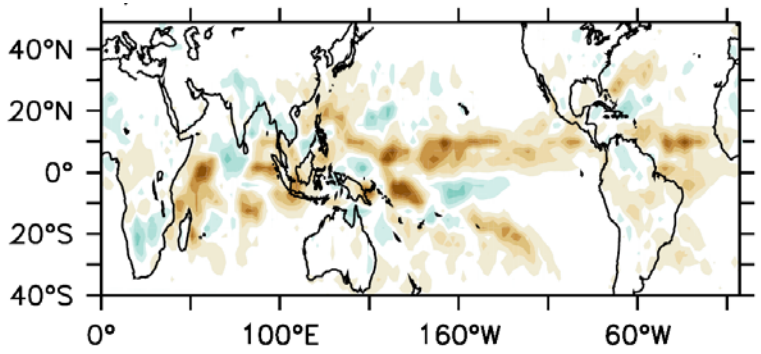
Thank you


AGCM
CGCM
(a) Cloud Fraction
(b) Cloud Fraction
(c) Relative Humidity
(d) Relative Humidity
200
400
600
800
1000
40°S 20°S 0° 20°N 40°N
1.5
1.3
1.1
0.9
0.7
0.5
0.3
0.1
−0.1
−0.3
−0.5
−0.7
−0.9
−1.1
−1.3
−1.5
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0
−0.3
−0.6
−0.9
−1.2
−1.5
−1.8
−2.1
−2.4

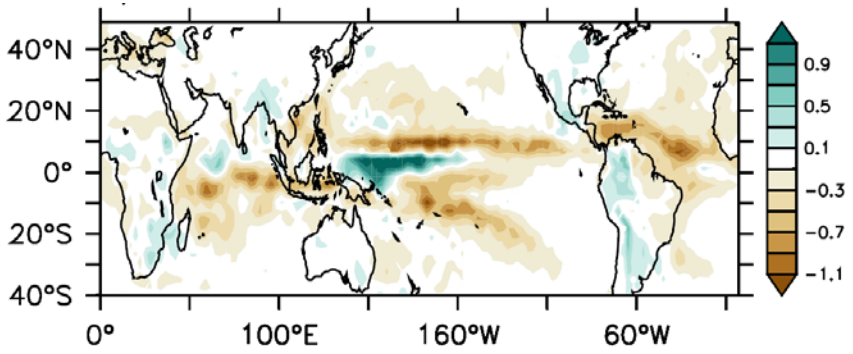
Experiments	Description
CGCM-CTRL	Control run of the coupled model
CGCM-2CO_2	Coupled model run with doubling CO_2 (5 ensembles for the first 5 years)
CGCM-HEAT	Coupled model run with upper-tropospheric heating (5 ensembles for the first 5 years)
AGCM-CTRL	AGCM control run with prescribed climatological SST and sea ice
AGCM-2CO_2	AGCM run with doubling CO_2
AGCM-HEAT	AGCM run with upper-tropospheric heating

What results in more moisture near the surface?

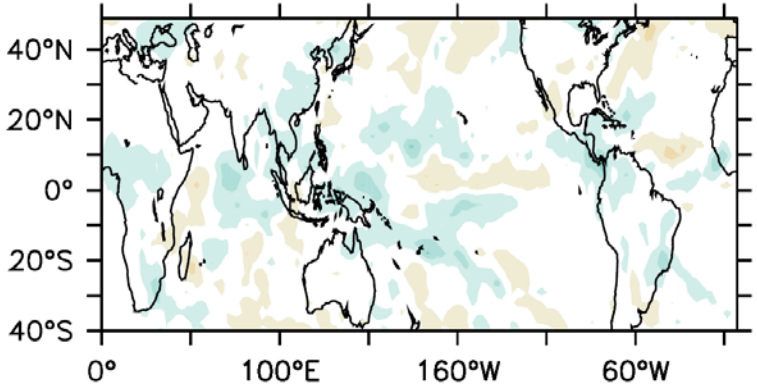
Convective Precipitation (AGCM)



Convective Precipitation (CGCM)



Large-scale Precipitation (AGCM)



Large-scale precipitation (CGCM)