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1 1 . 9)

Global Warming Simulation by using the High-Resolution Climate model (K-1 Model)



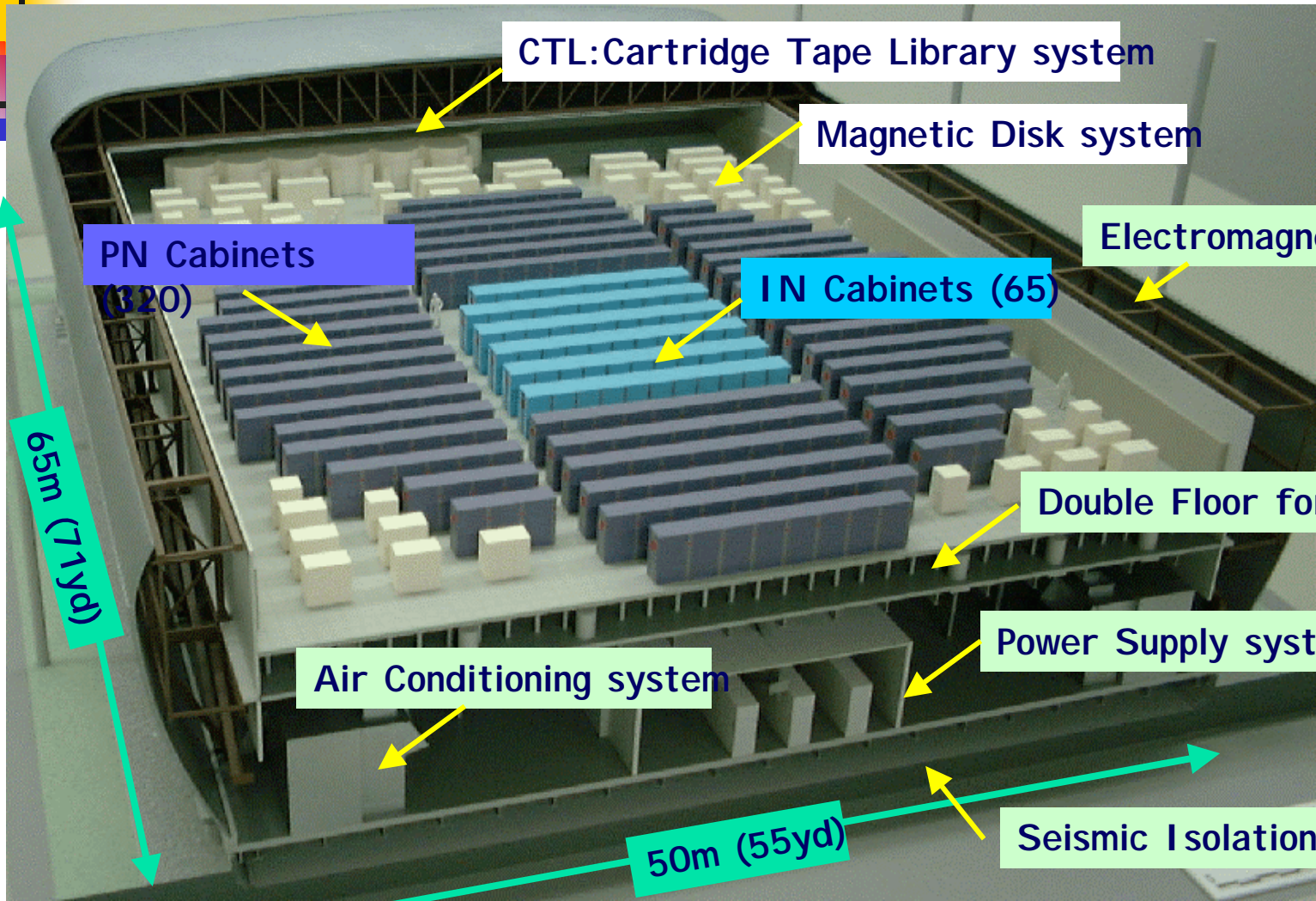
Akimasa Sumi

Center for Climate System Research

University of Tokyo

The Earth Simulator





CTL: Cartridge Tape Library system

Magnetic Disk system

PN Cabinets
(320)

IN Cabinets (65)

Electromagnetic Shield

65m (71yd)

Double Floor for cables

Air Conditioning system

Power Supply system

50m (55yd)

Seismic Isolation system

TOP500 List for November 2002

R_{\max} and R_{peak} values are in GFlops. For more details about other fields, please click on the button "Explanation of the Fields"



DETAILS



EXPLANATION OF THE FIELDS

Rank	Manufacturer Computer/Process	R_{\max} R_{peak}	Installation Site Country/Year
1	NEC Earth-Simulator/ 5120	35860.00 40960.00	<u>Earth Simulator Center</u> Japan/2002
2	Hewlett-Packard ASCI Q - AlphaServer SC ES45/1.25 GHz/ 4096	7727.00 10240.00	<u>Los Alamos National Laboratory</u> USA/2002
3	Hewlett-Packard ASCI Q - AlphaServer SC ES45/1.25 GHz/ 4096	7727.00 10240.00	<u>Los Alamos National Laboratory</u> USA/2002
4	IBM ASCI White, SP Power3 375 MHz/ 8192	7226.00 12288.00	<u>Lawrence Livermore National Laboratory</u> USA/2000
5	Linux NetworX MCR Linux Cluster Xeon 2.4 GHz - Quadrics/ 2304	5694.00 11060.00	<u>Lawrence Livermore National Laboratory</u> USA/2002



K-1 Climate Model

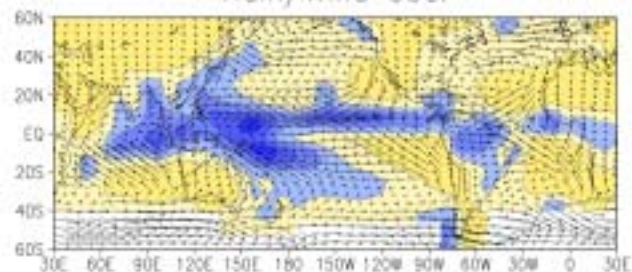
- High resolution Climate Model
- T106L56+1/4x1/6 L48
- On-line Aerosol model(5 species of aerosols, such as Dust, Sea Salt, Sulfate, BC, and OC)
- Earth Simulator
- IPCC AR4



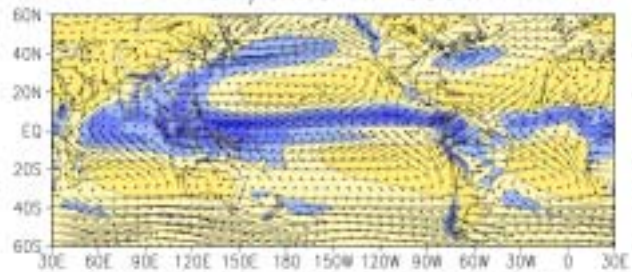
Model Performance

- Small scale features and large-scale features
- Orography related phenomena
- Moisture fields

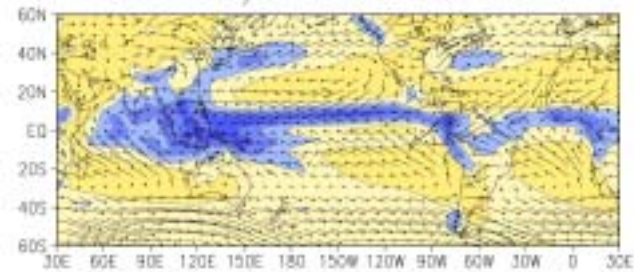
Rain/Wind Obs.



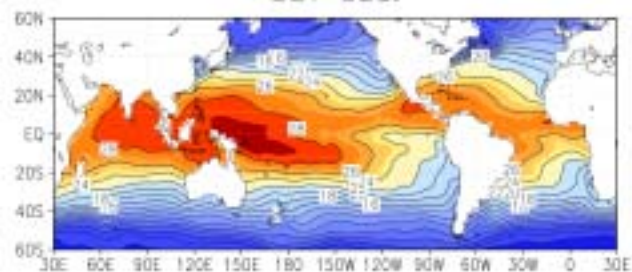
Rain/Wind Hi-CGCM



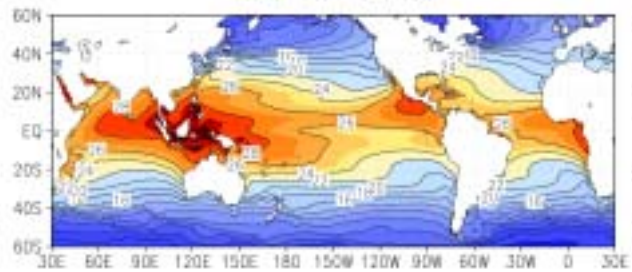
Rain/Wind Mid-CGCM



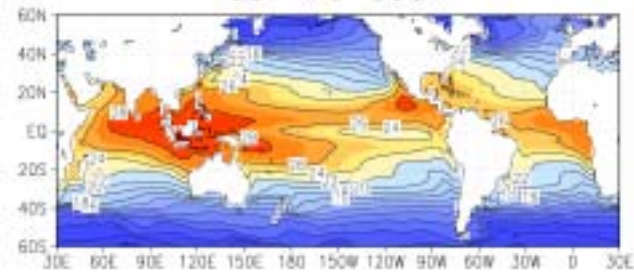
SST Obs.



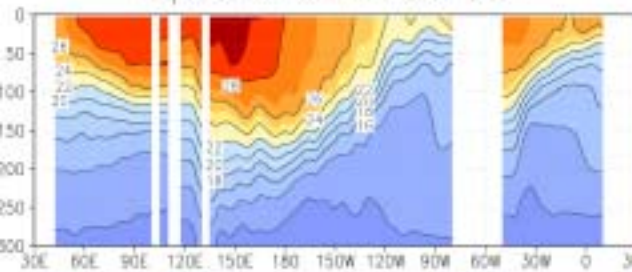
SST Hi-CGCM



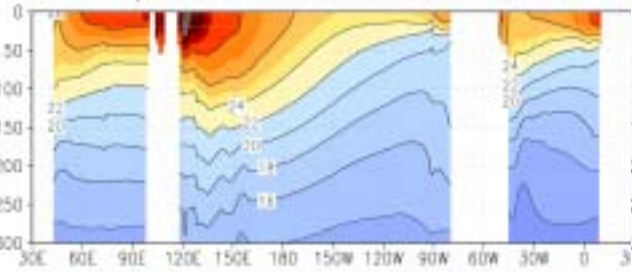
SST Mid-CGCM



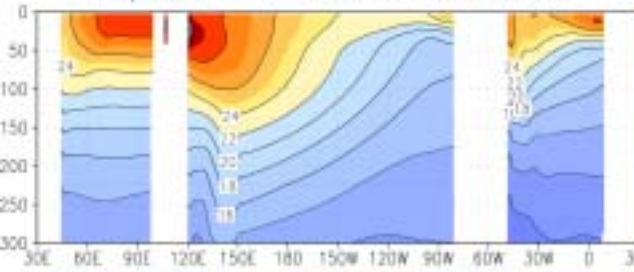
Equatorial X-section Obs.



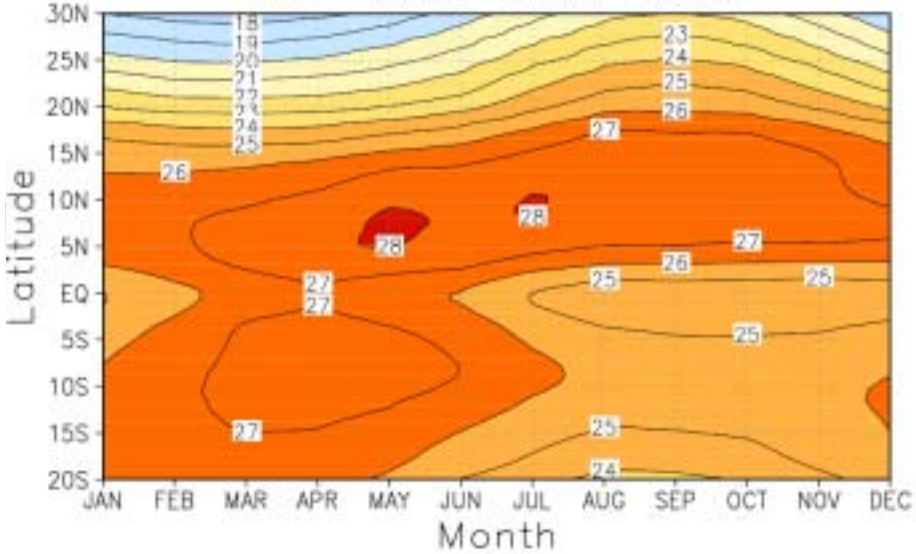
Equatorial X-section Hi-CGCM



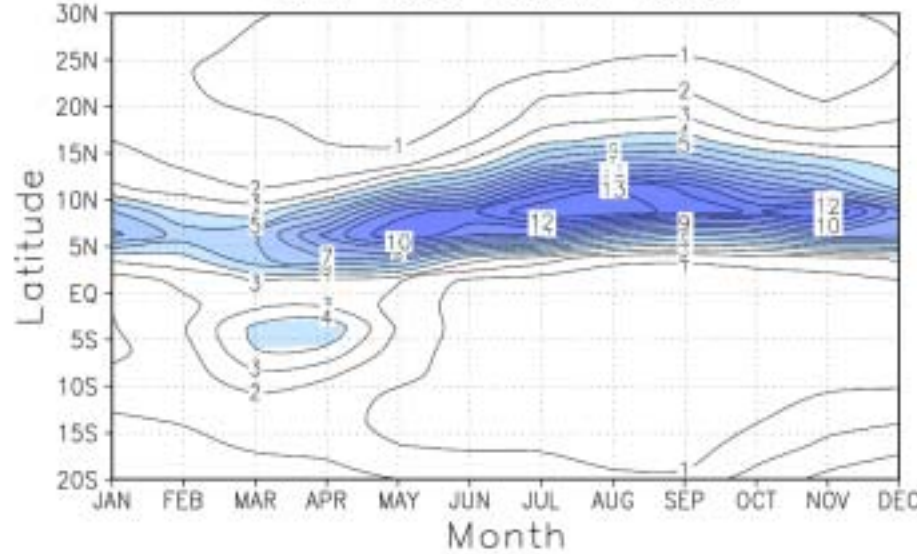
Equatorial X-section Mid-CGCM



SST Obs. 150W-100W

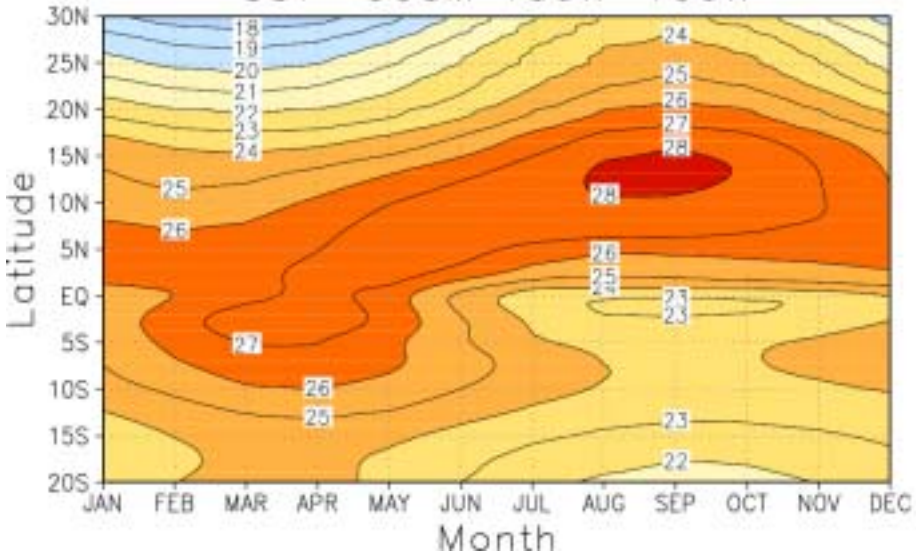


Rain Obs. 150W-100W

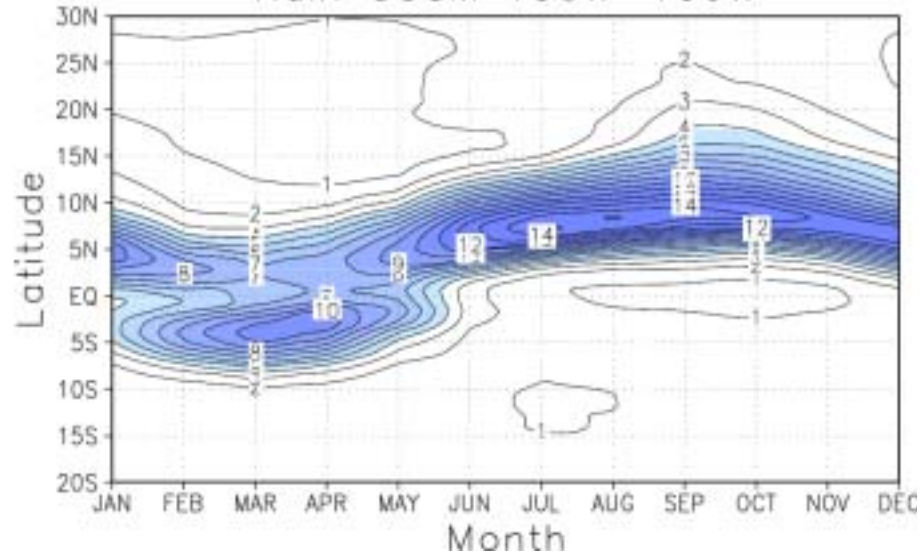


Hi-CGCM

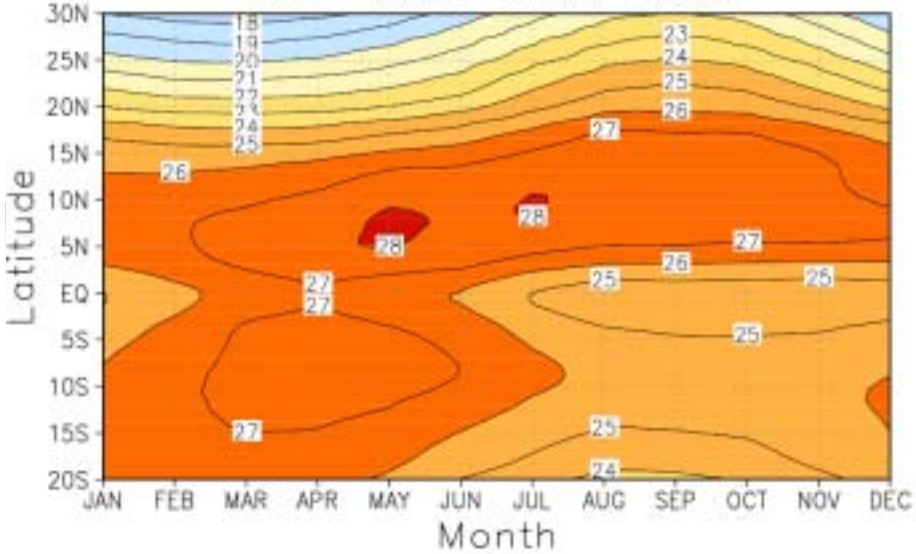
SST CGCM 150W-100W



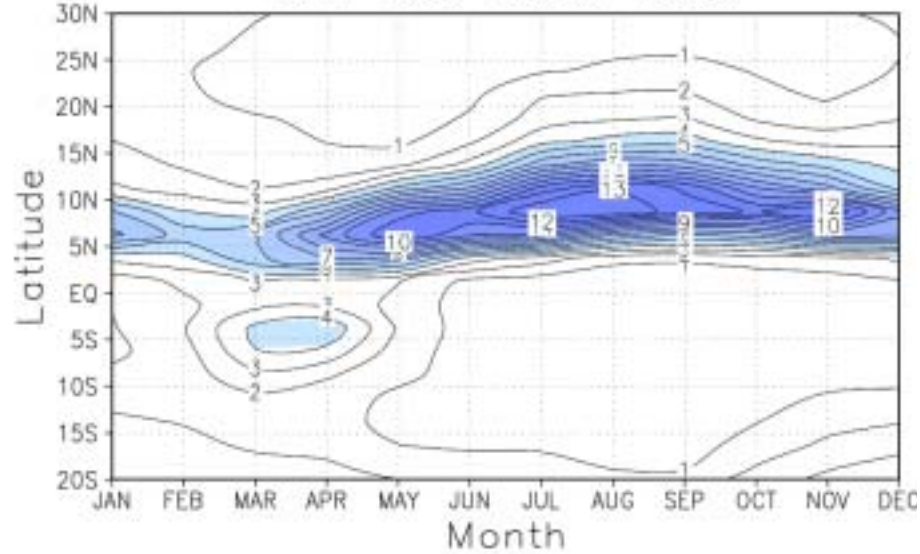
Rain CGCM 150W-100W



SST Obs. 150W-100W

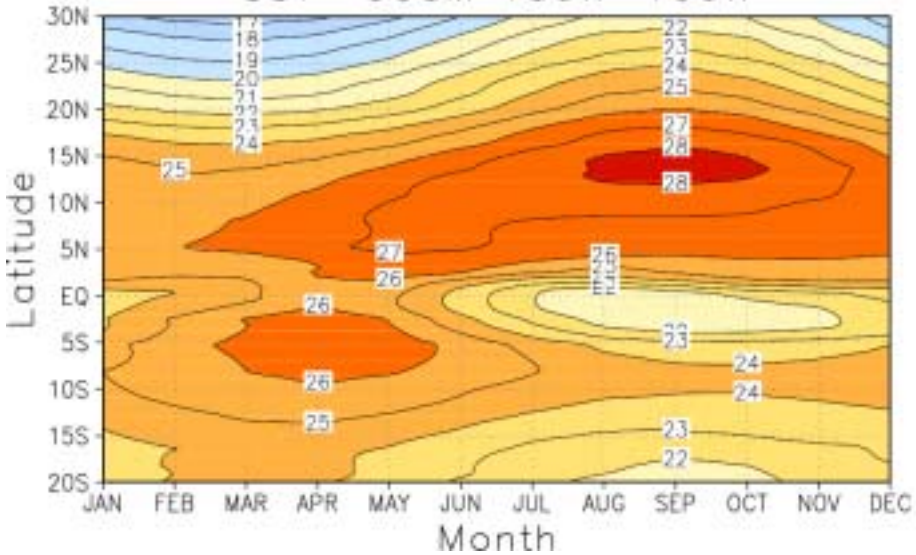


Rain Obs. 150W-100W

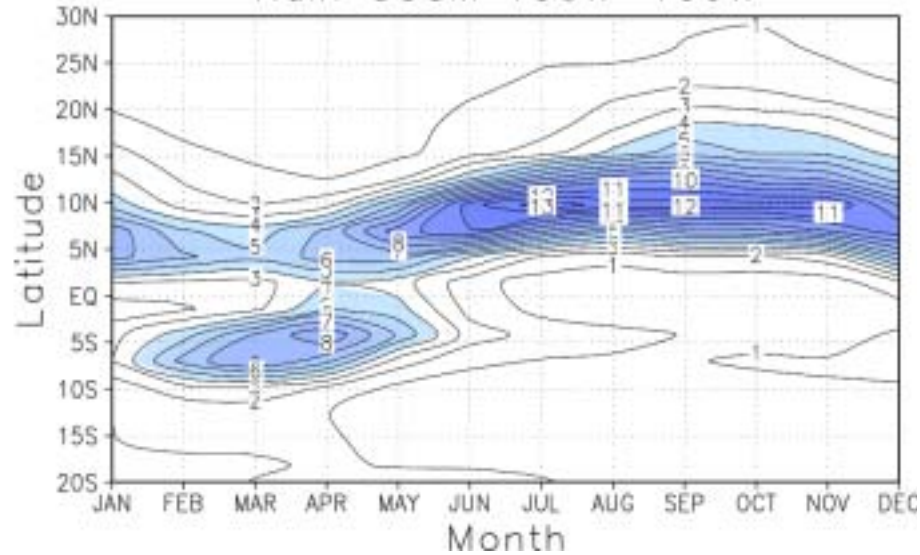


Mid-CGCM

SST CGCM 150W-100W

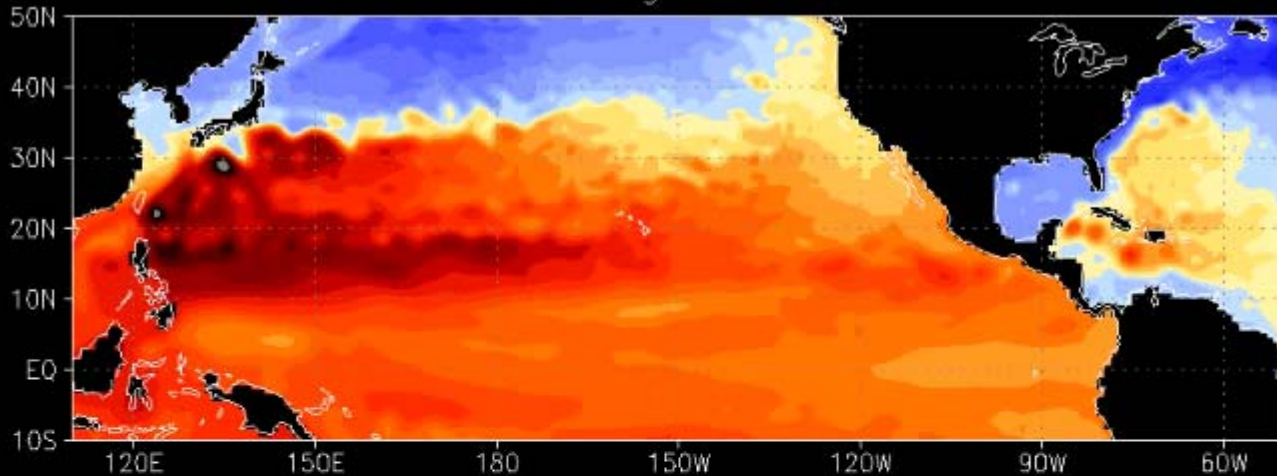


Rain CGCM 150W-100W

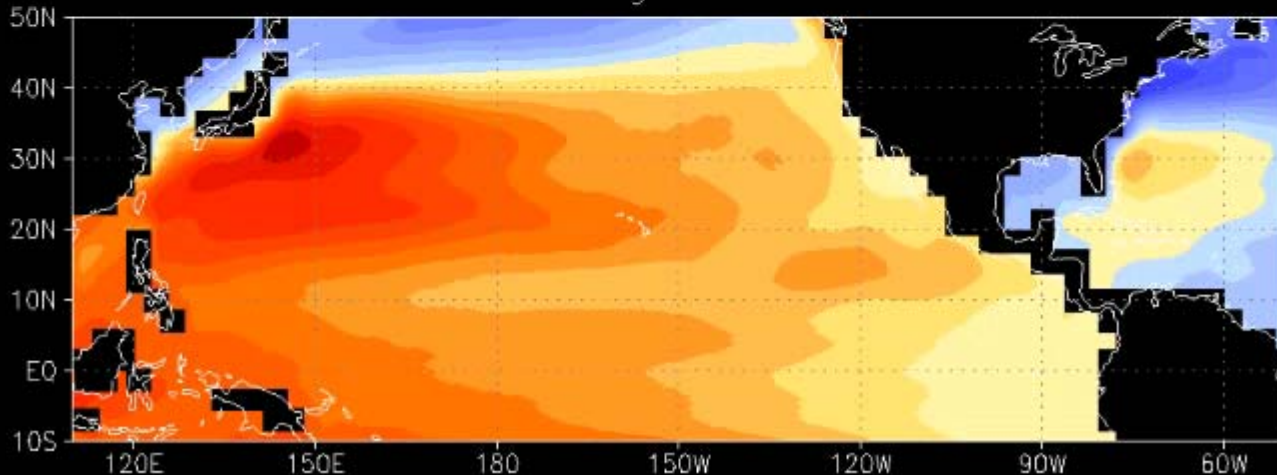


Hi-CGCM: a pilot 40-yr integration

Sea Surface Height Hi-CGCM JAN21



Sea Surface Height Mid-CGCM JAN21



1. Introduction

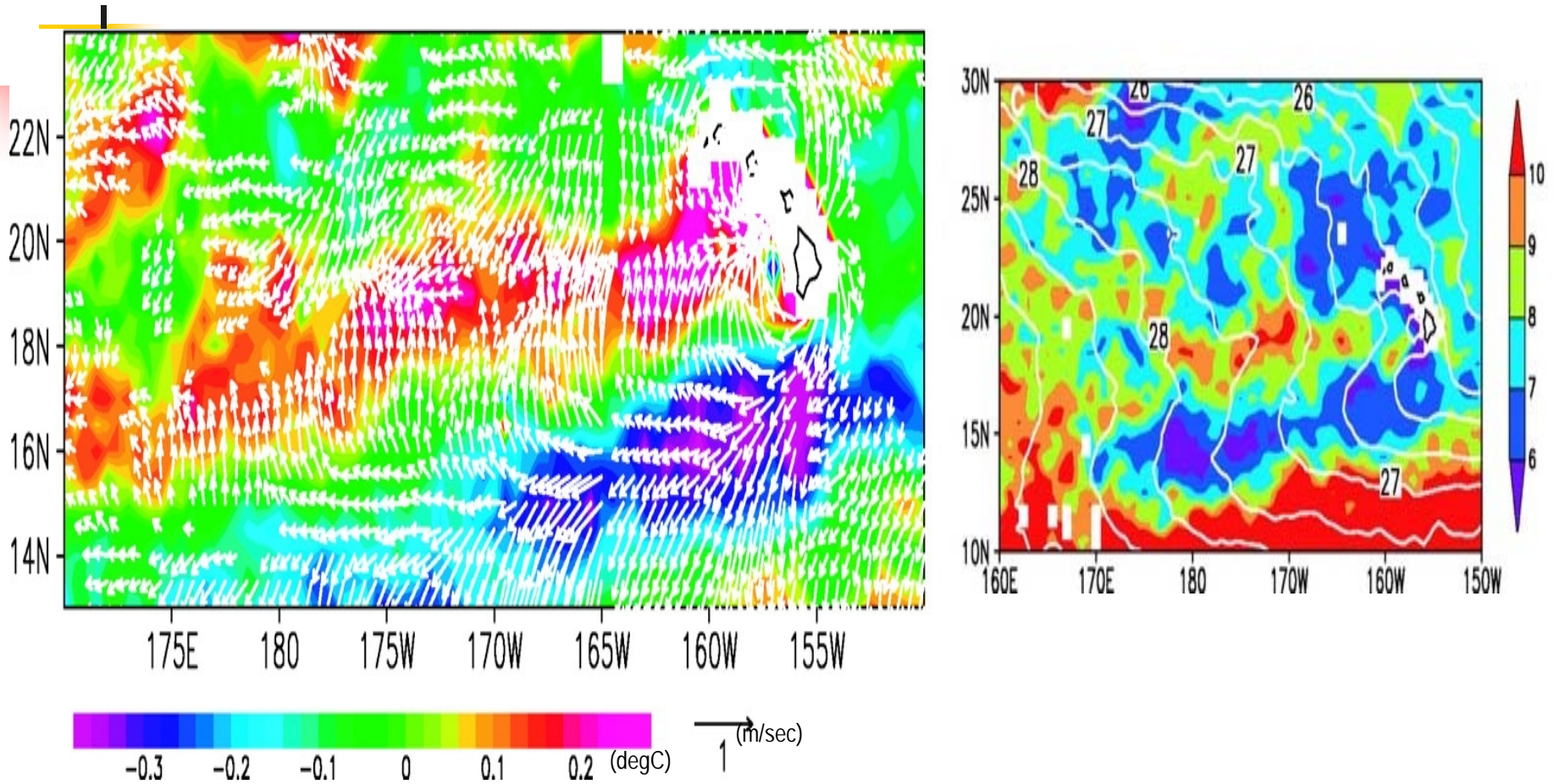


Figure 1. SST and surface wind anomaly from meridionally 8-degree moving averaged fields (a), and cloud liquid water (b) averaged from July to October 1999 (Xie et al. 2001). SST and cloud liquid water are observed from TRMM and surface wind is from QuickSCAT.

3. Results

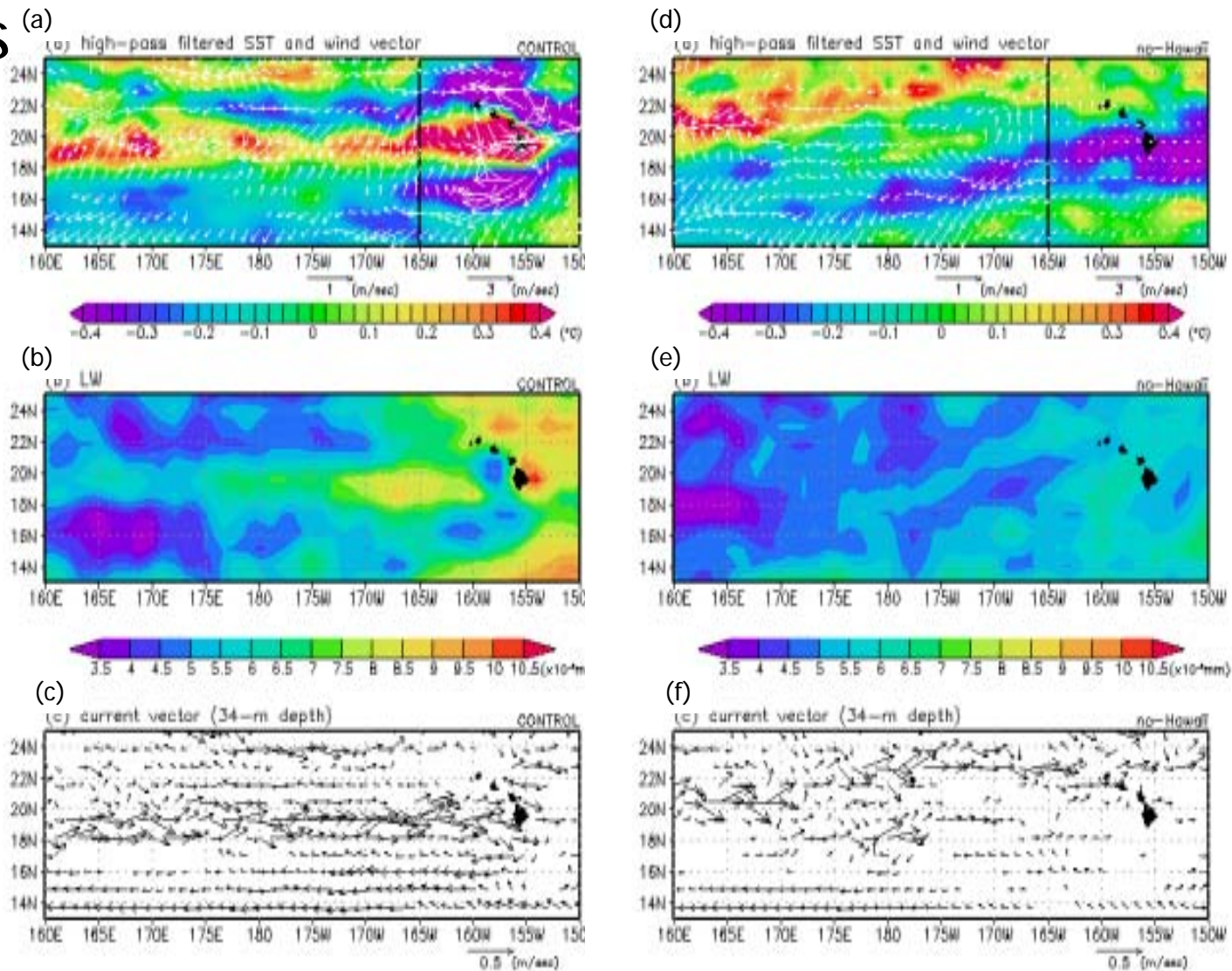
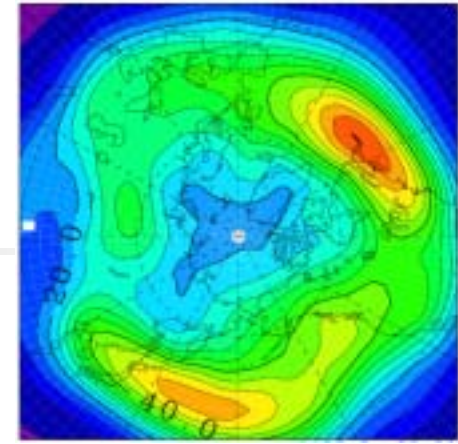
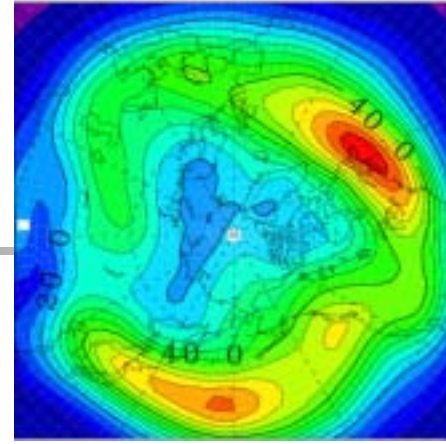
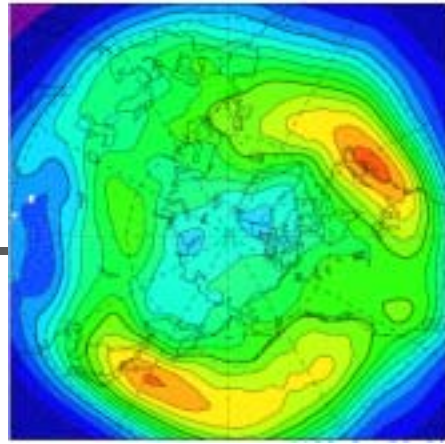
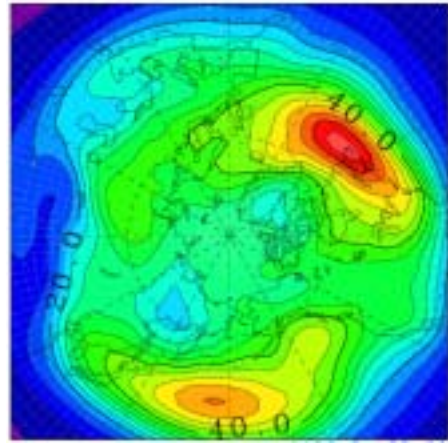


Figure 2. (a, d) High-pass filtered SST by color and surface wind (vectors). (b, e) Vertically integrated liquid water. (c, f) Ocean current vectors at 34-m depth. Left panels (a-c) are from the control run and right panels (d-f) are from the no-Hawaii run. All panels show the averages from July to October of the 33rd year.

NH DJF

Highpass (2.5-6day) Eddy

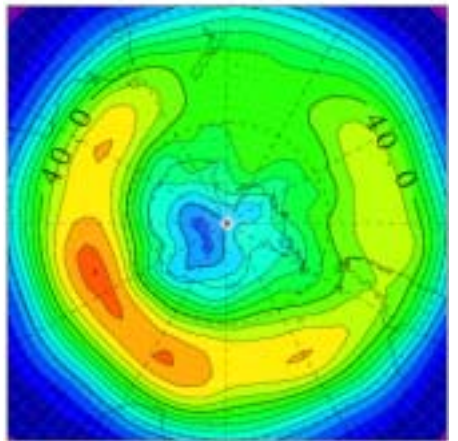
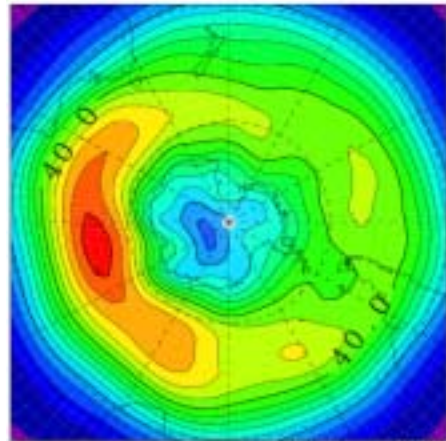
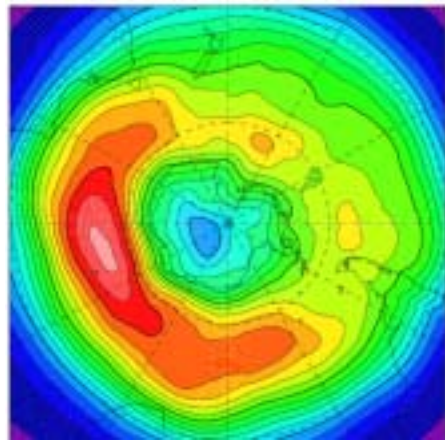
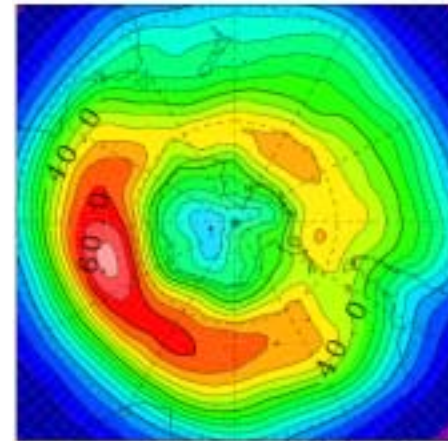


ERA40
SH JJA

T106L56
AGCM

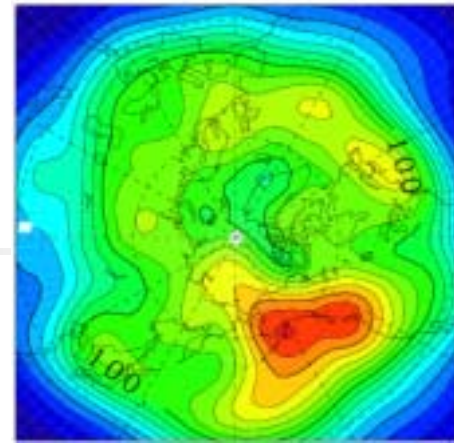
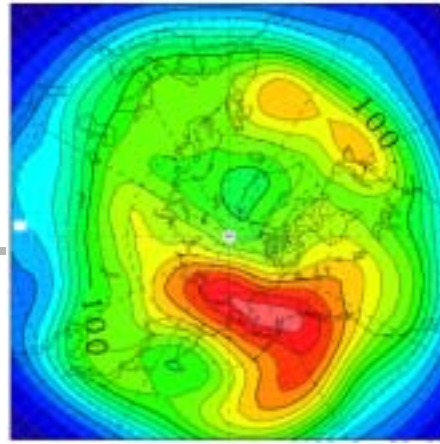
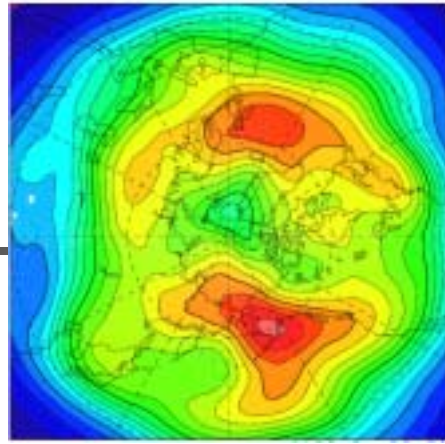
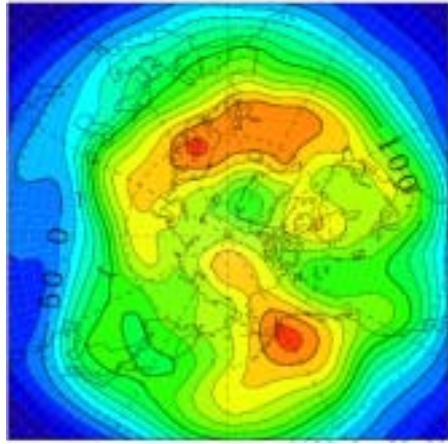
T42L56
AGCM

T42L20
AGCM



NH DJF

Lowpass (10-90day) Eddy

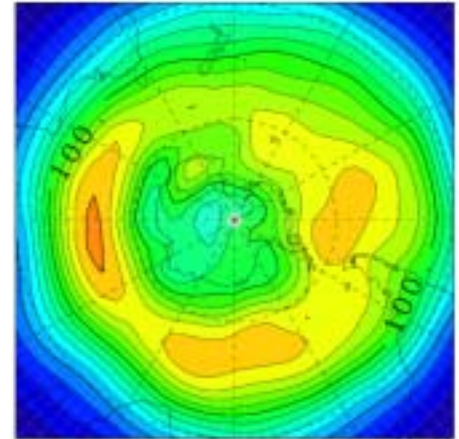
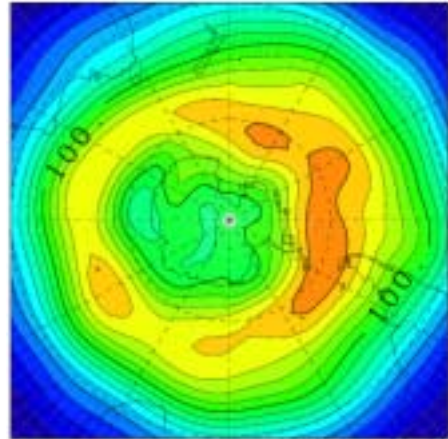
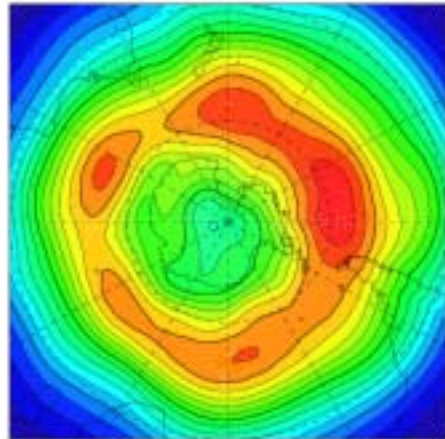
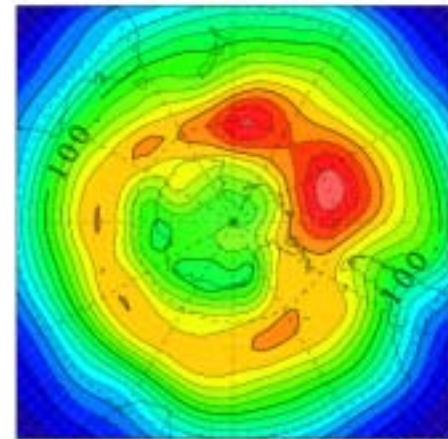


ERA40
SH JJA

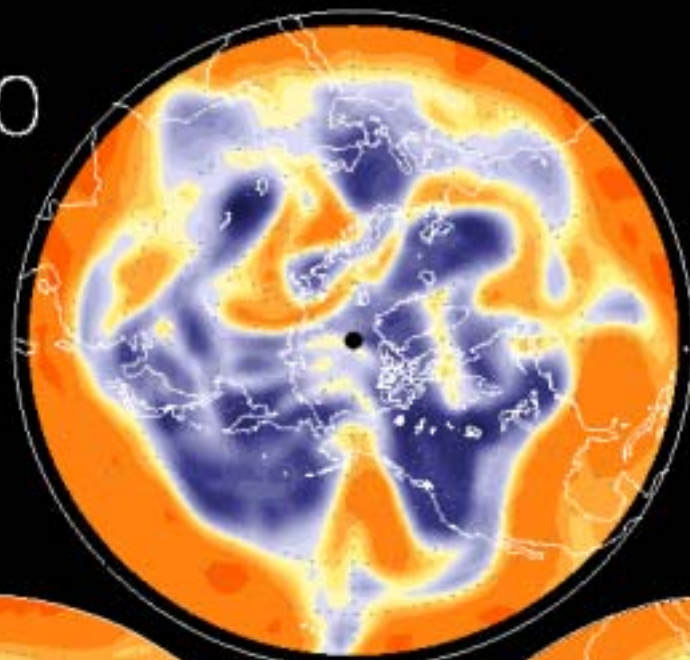
T106L56
AGCM

T42L56
AGCM

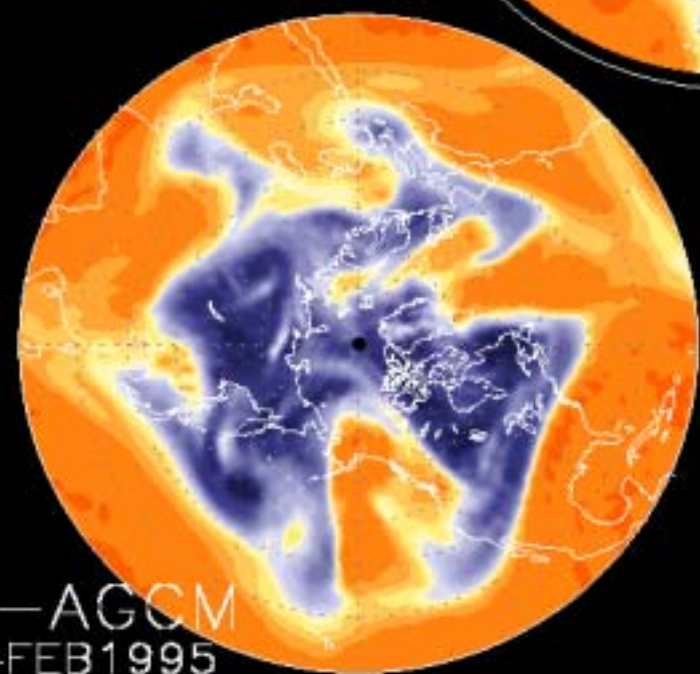
T42L20
AGCM



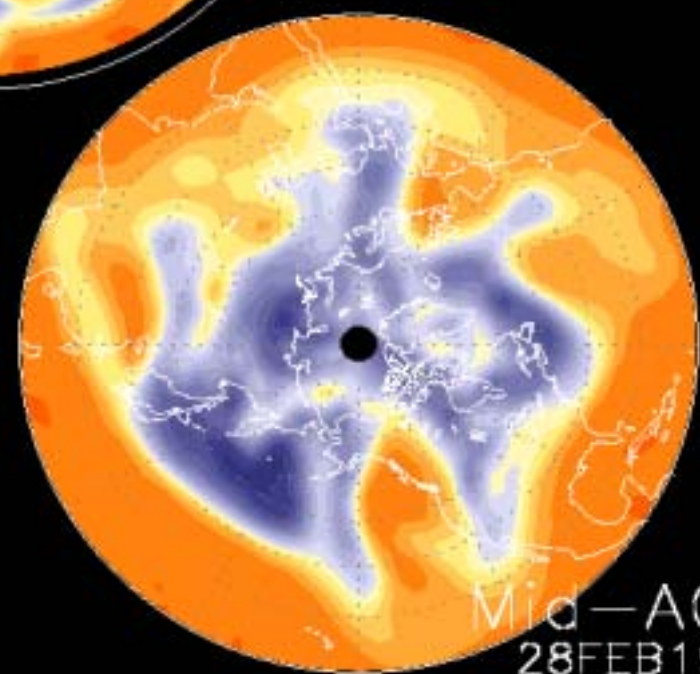
PV250



Obs.
25 FEB 1996

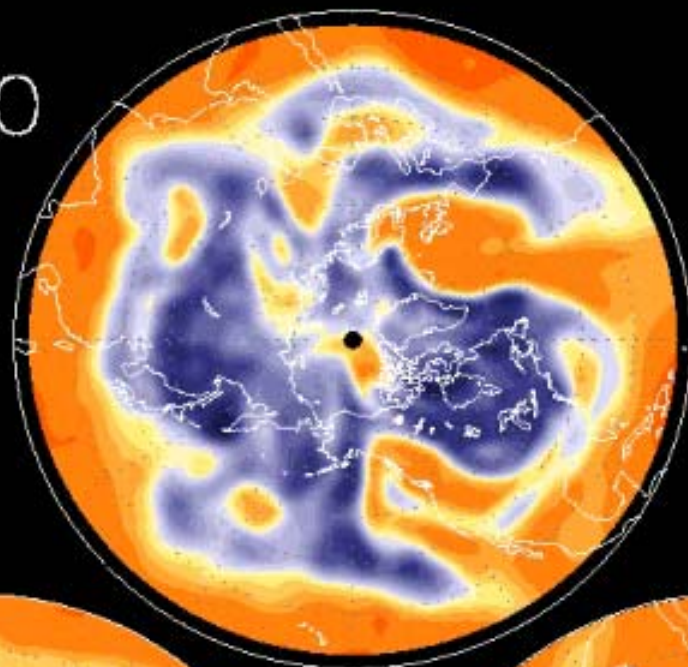


Hi-AGCM
14 FEB 1995

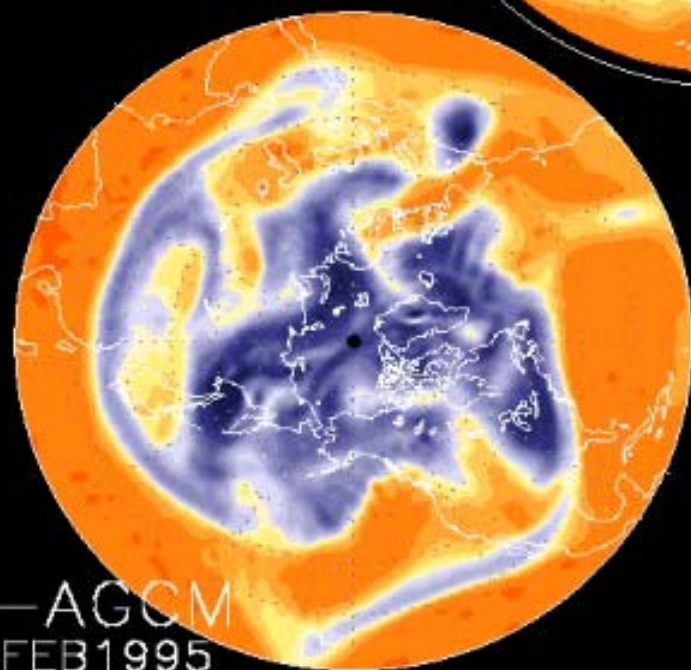


Mid-AGCM
28 FEB 1997

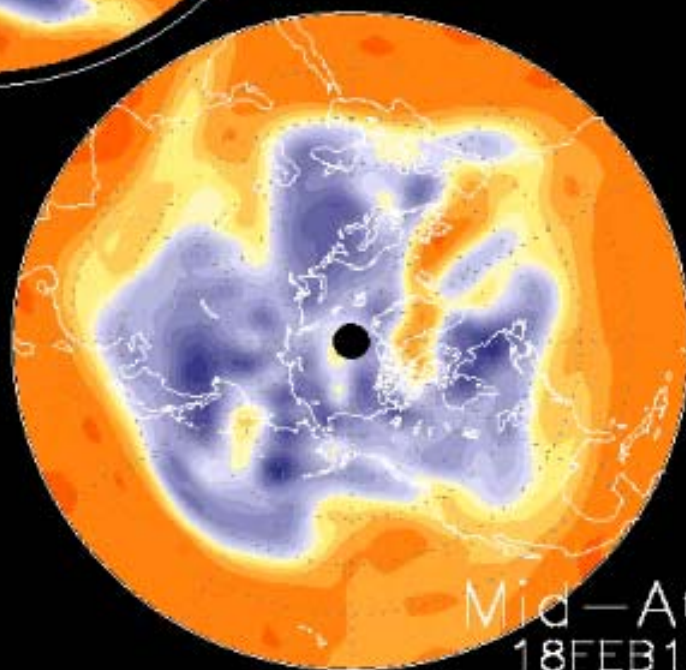
PV250



Obs.
15FEB1996

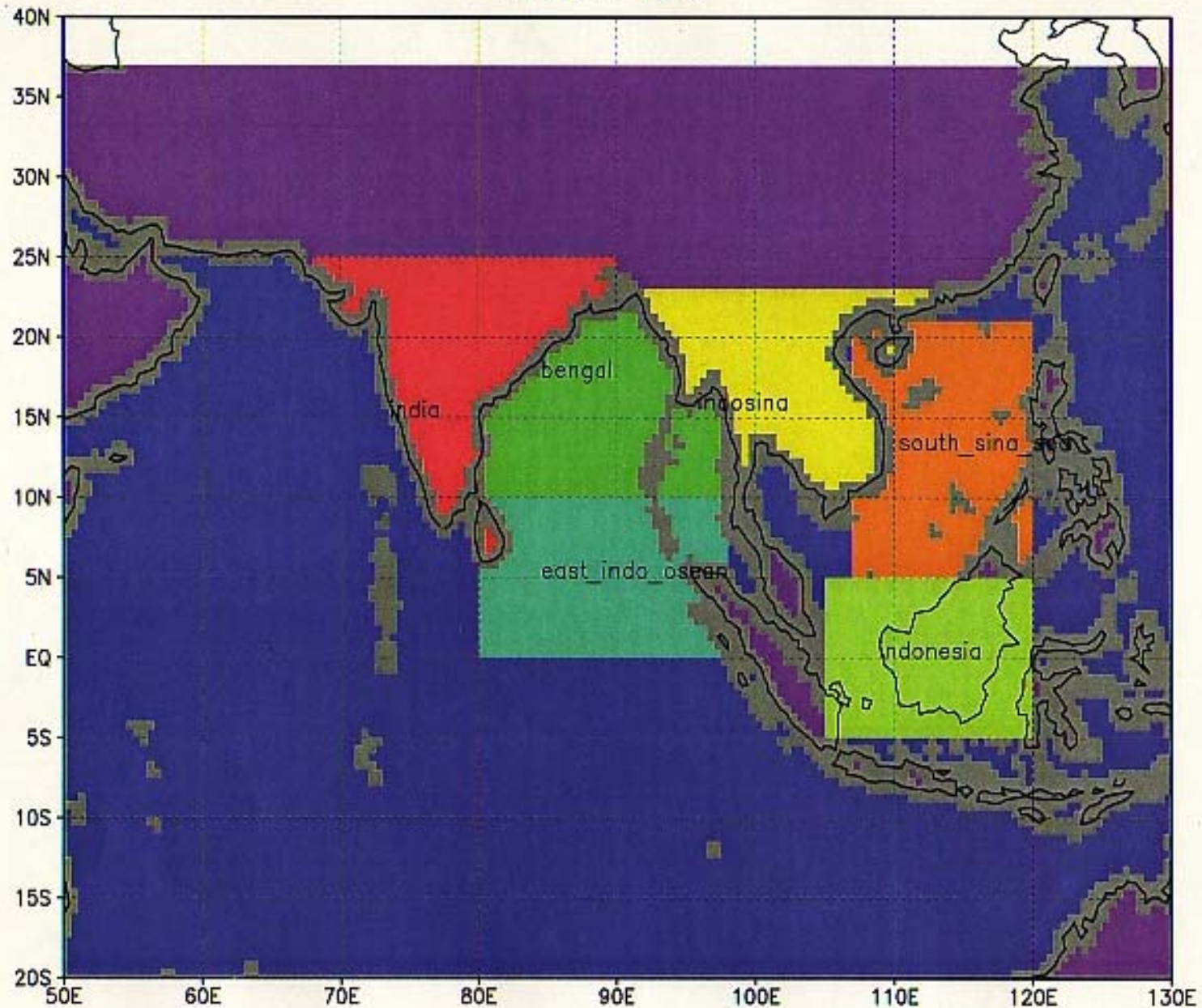


Hi-AGCM
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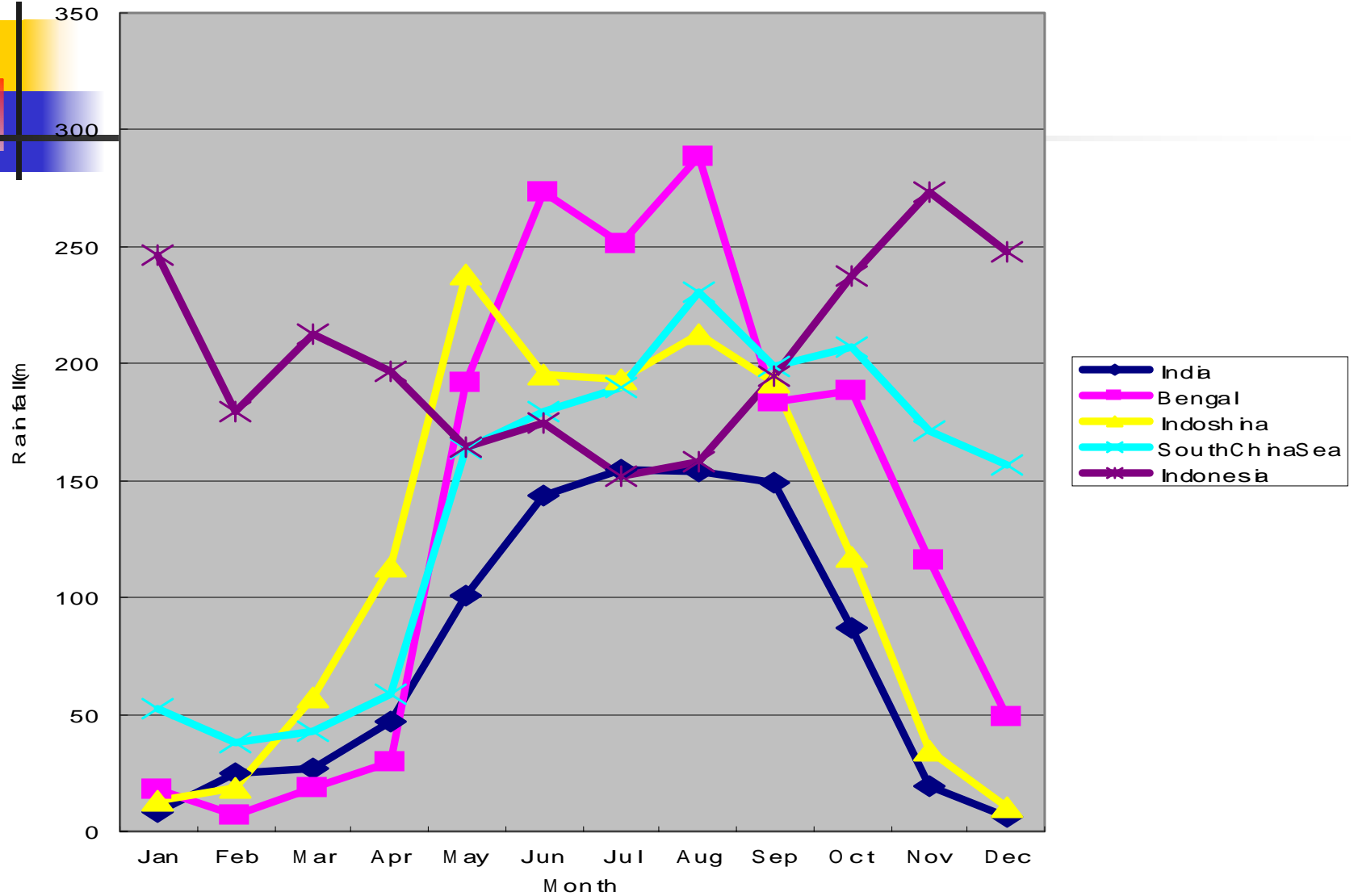
Mid-AGCM
18FEB1997

AREA MAP

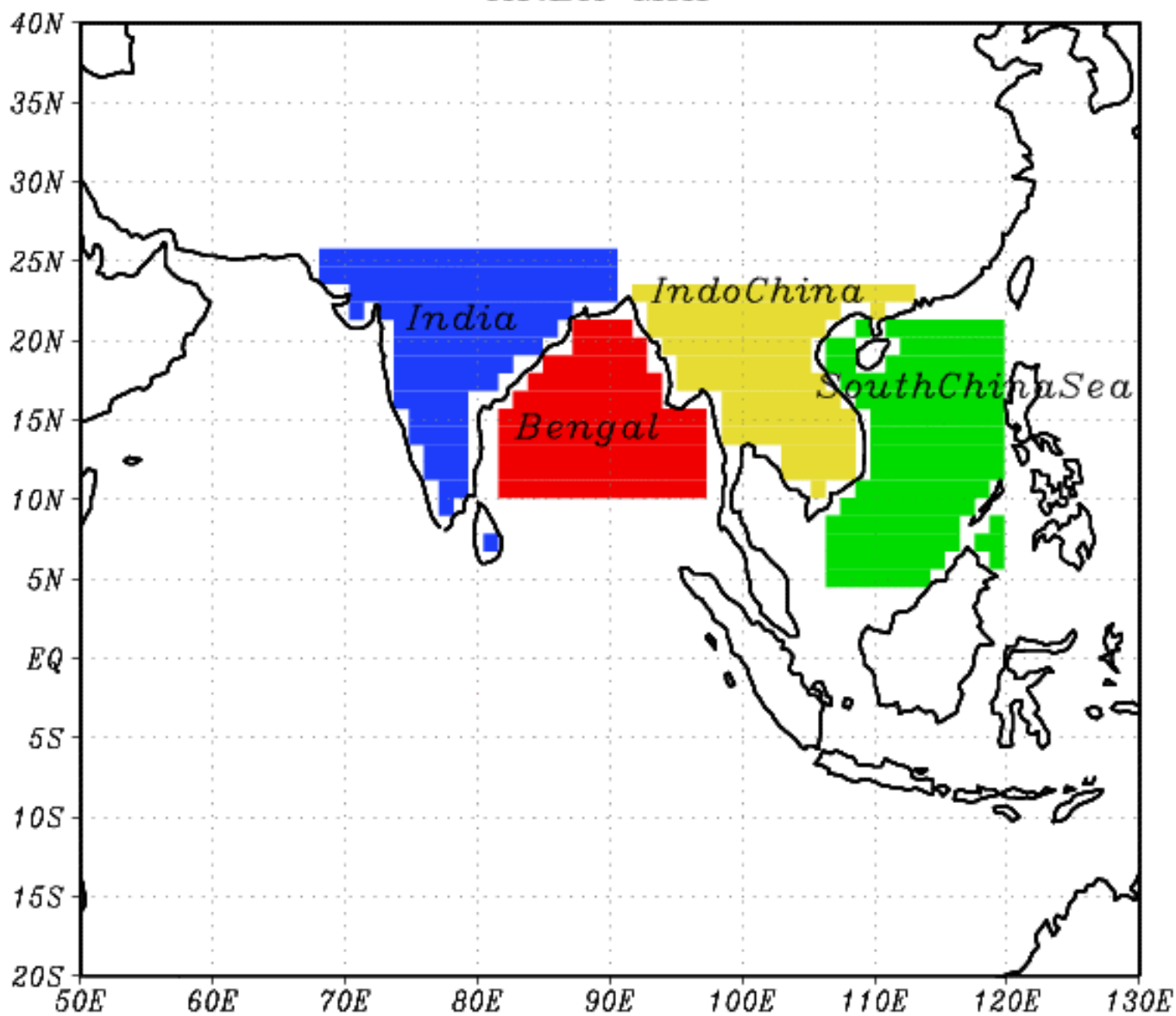


6 year Ave.

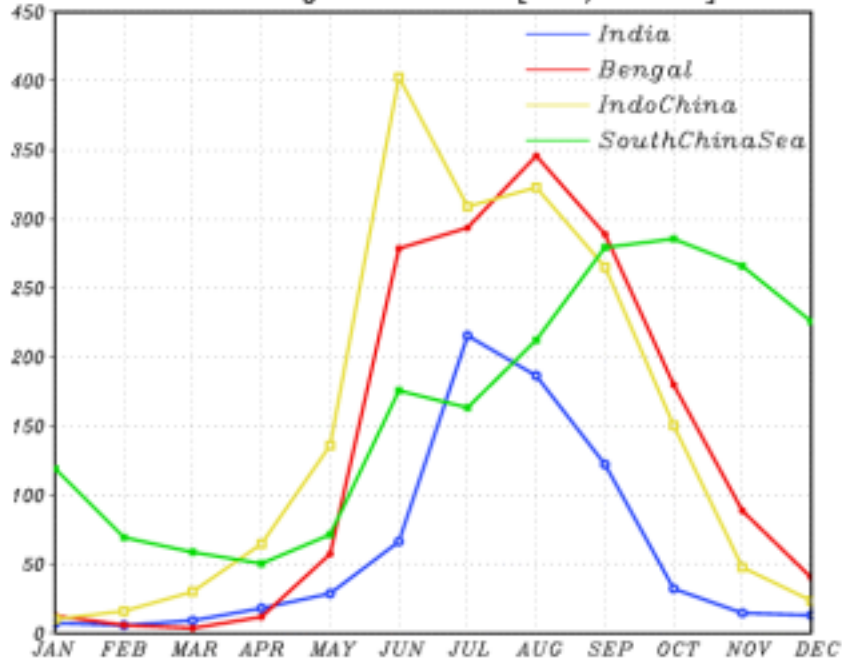
6 year Ave



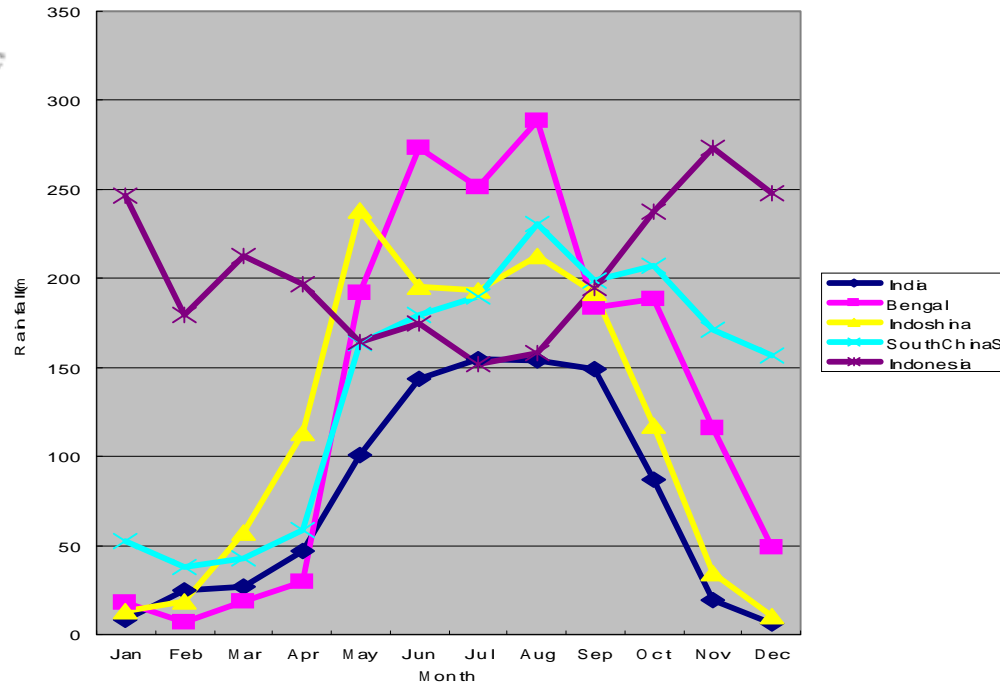
AREA MAP



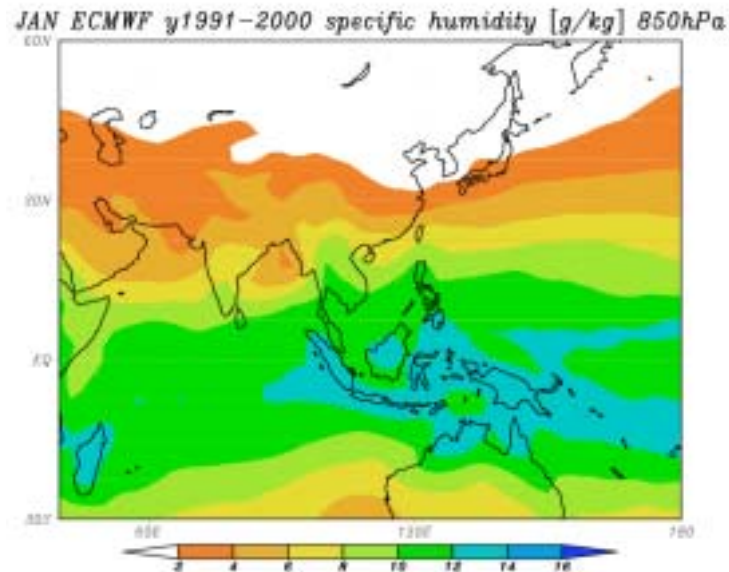
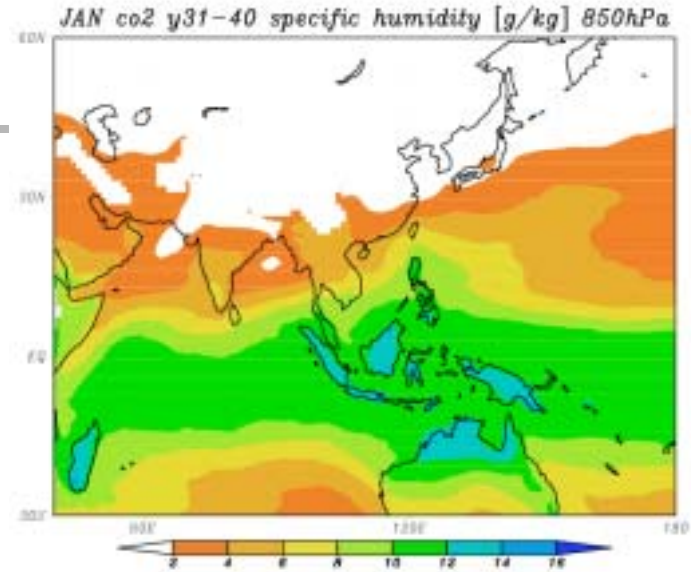
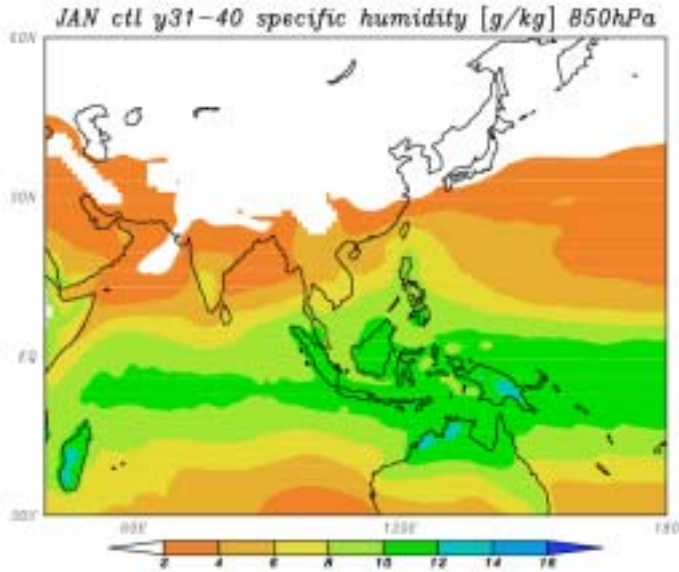
CCCM ctl y31-40 rain [mm/month]



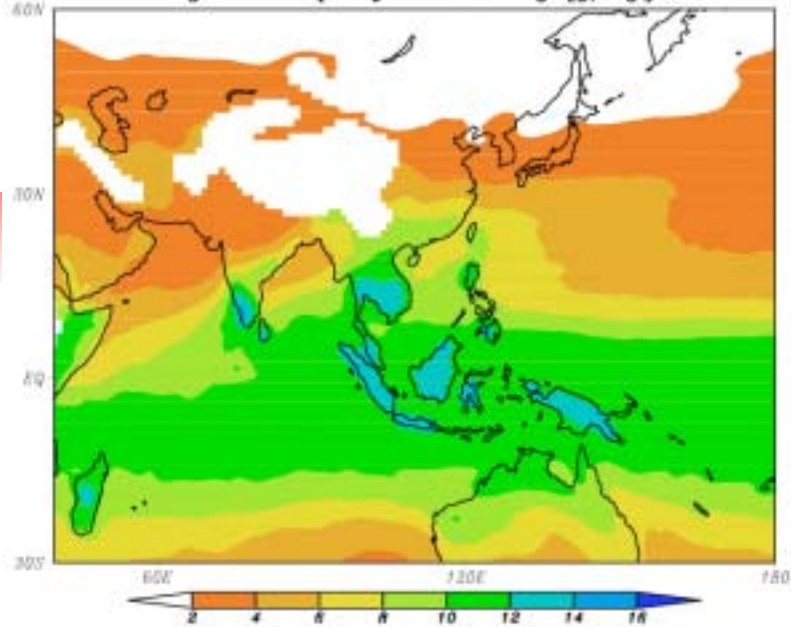
6 year Ave



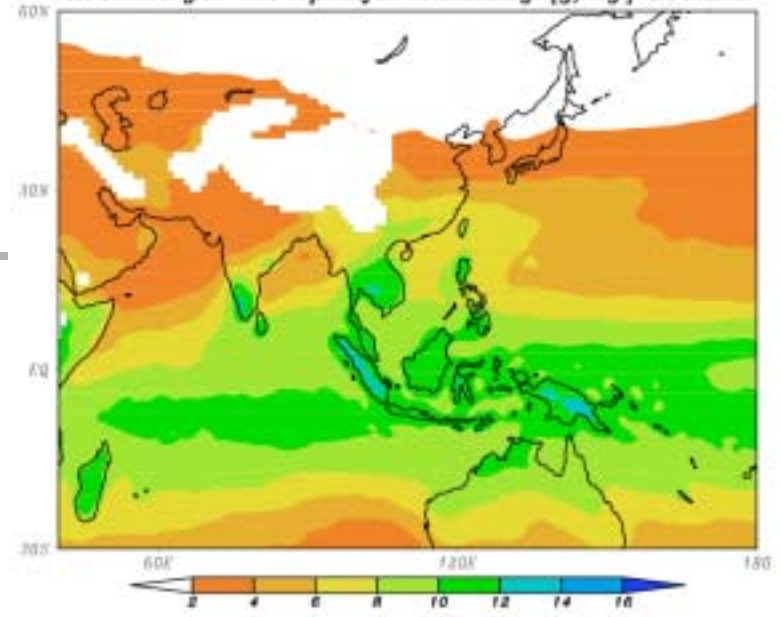
Specific humidity at 850hPa



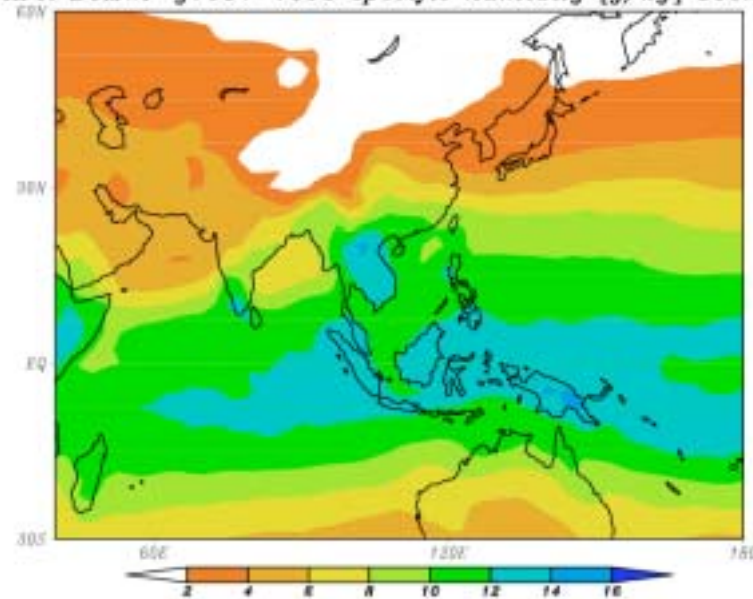
APR co2 y31-40 specific humidity [g/kg] 850hPa



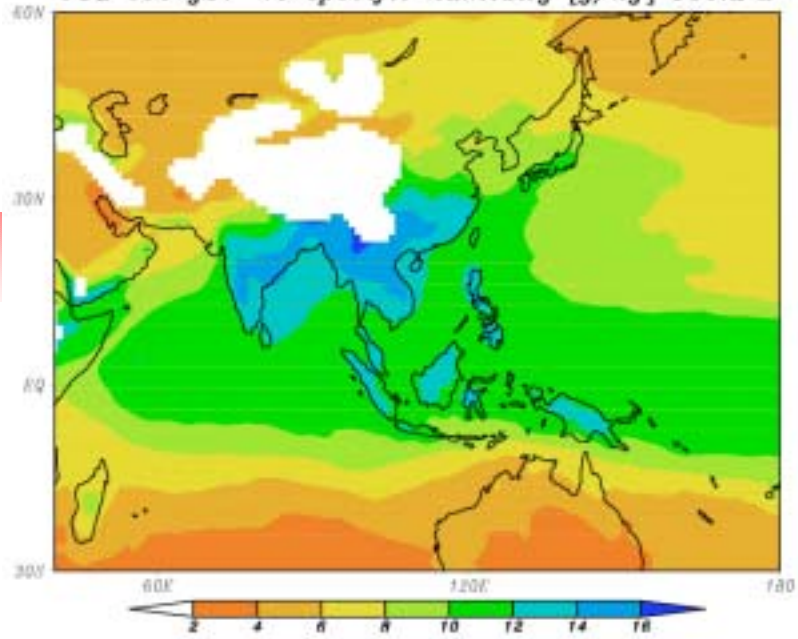
APR ctl y31-40 specific humidity [g/kg] 850hPa



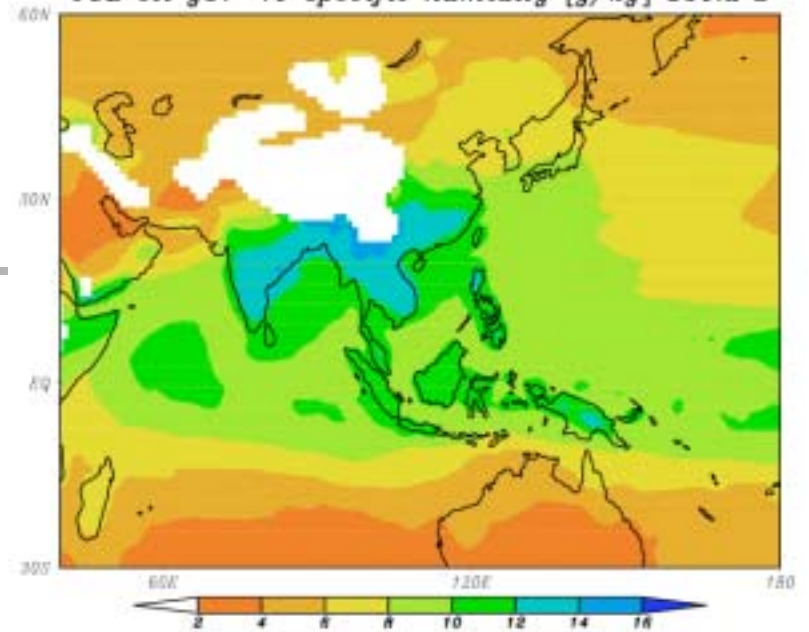
APR ECMWF y1984-1993 specific humidity [g/kg] 850hPa



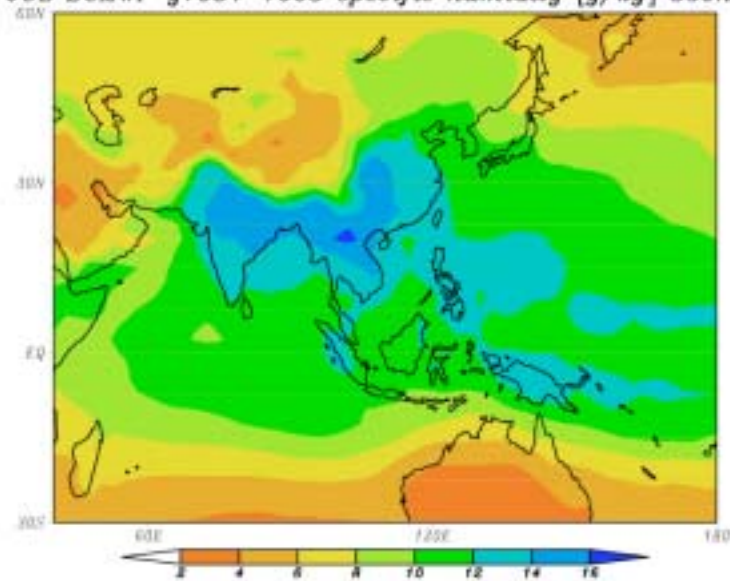
JUL co2 y31-40 specific humidity [g/kg] 850hPa



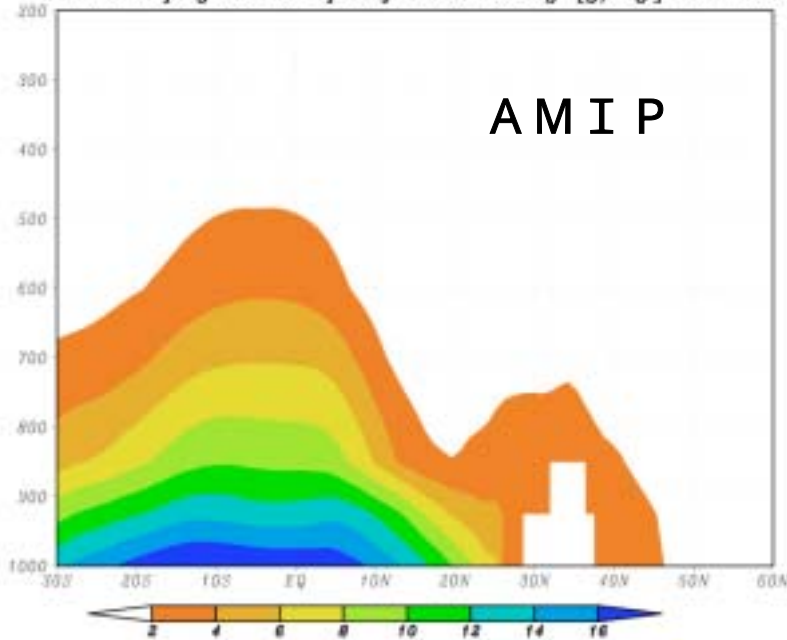
JUL ctl y31-40 specific humidity [g/kg] 850hPa



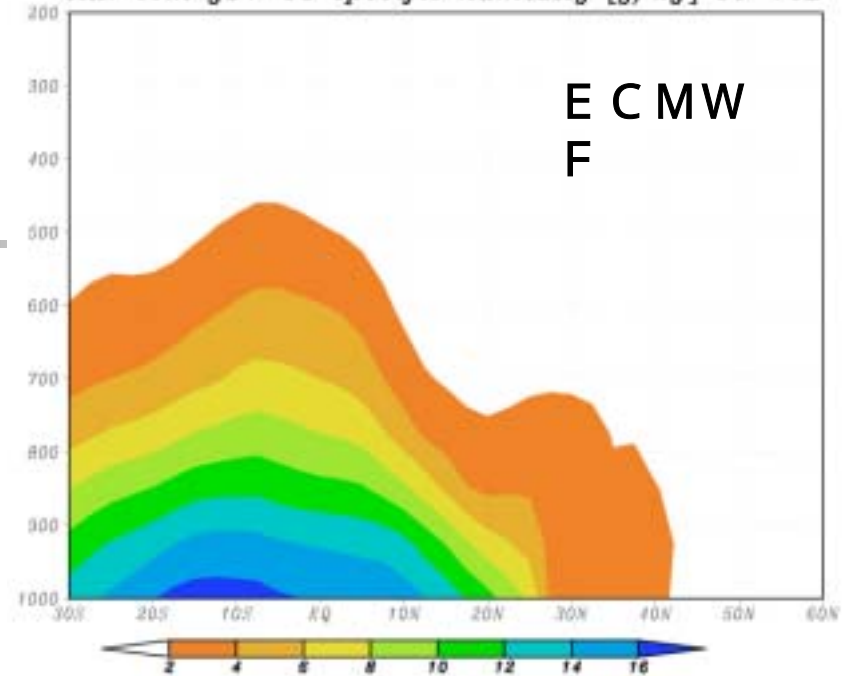
JUL ECMWF y1984-1993 specific humidity [g/kg] 850hPa



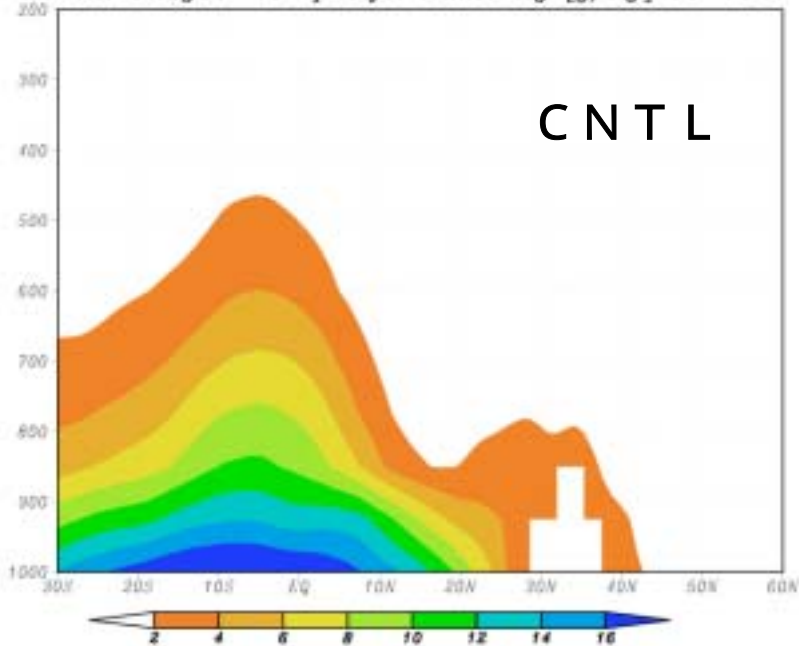
JAN amip y79-98 specific humidity [g/kg] 60-70E



JAN ecm y84-93 specific humidity [g/kg] 60-70E



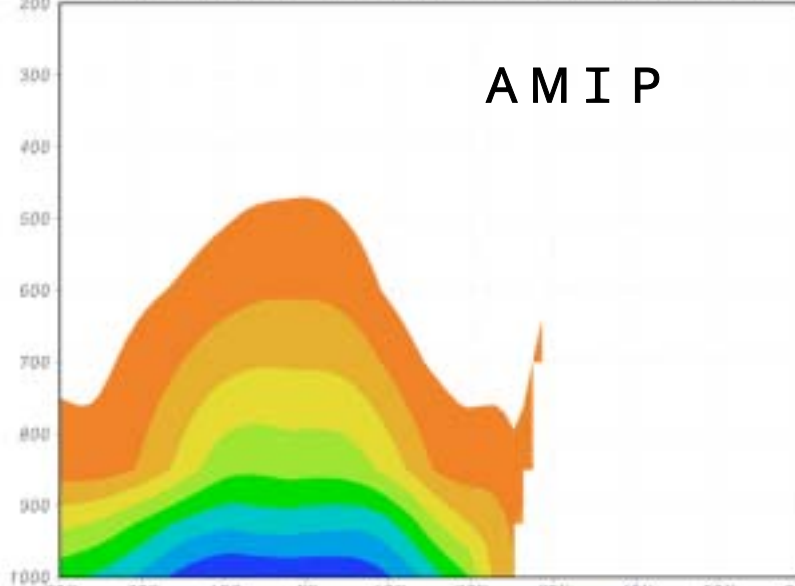
JAN ctl y31-40 specific humidity [g/kg] 60-70E



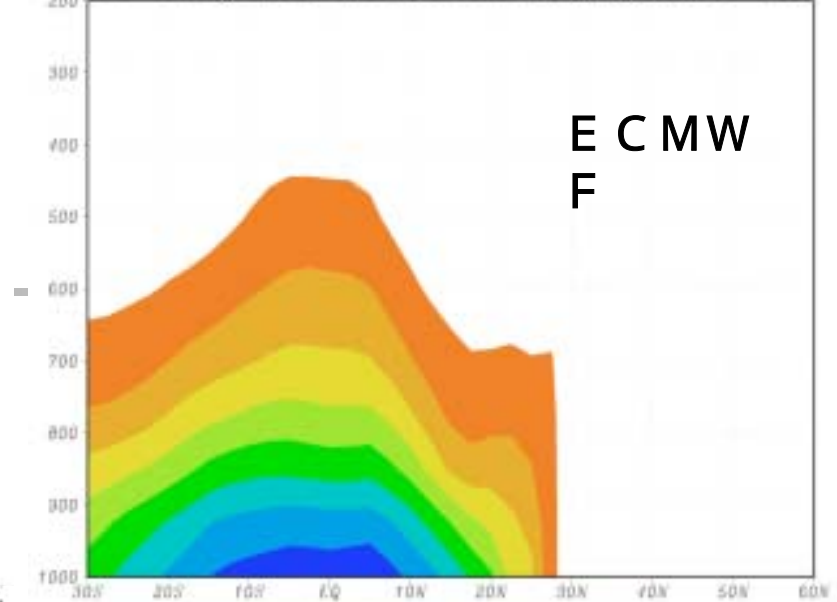
60 - 70 E

Arabian
Sea

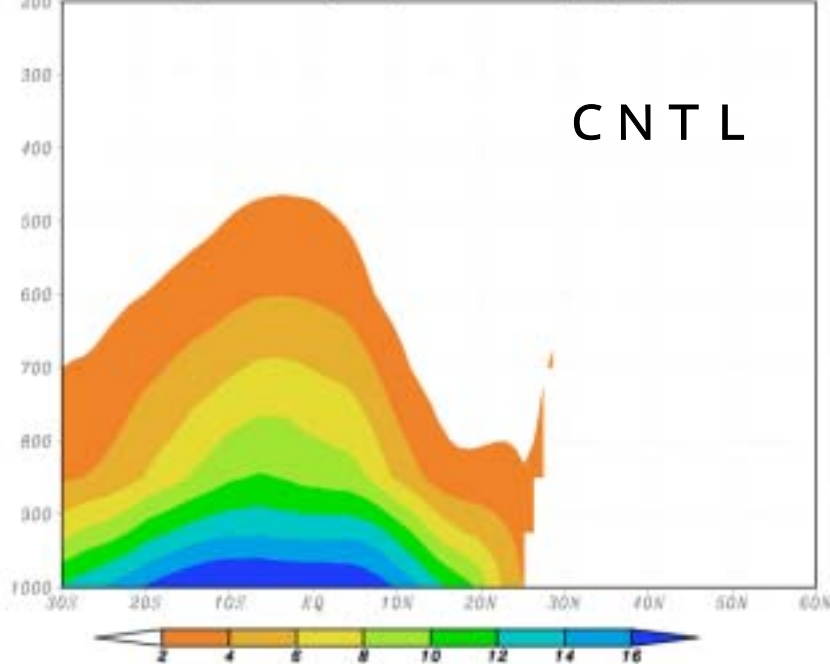
JAN amip y79-98 specific humidity [g/kg] 85-95E



JAN ecm y84-93 specific humidity [g/kg] 85-95E



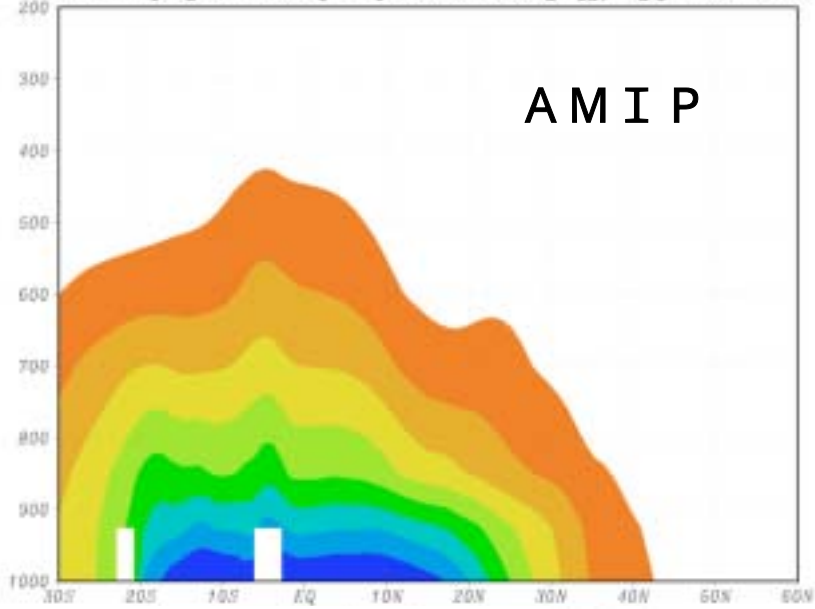
JAN ctl y31-40 specific humidity [g/kg] 85-95E



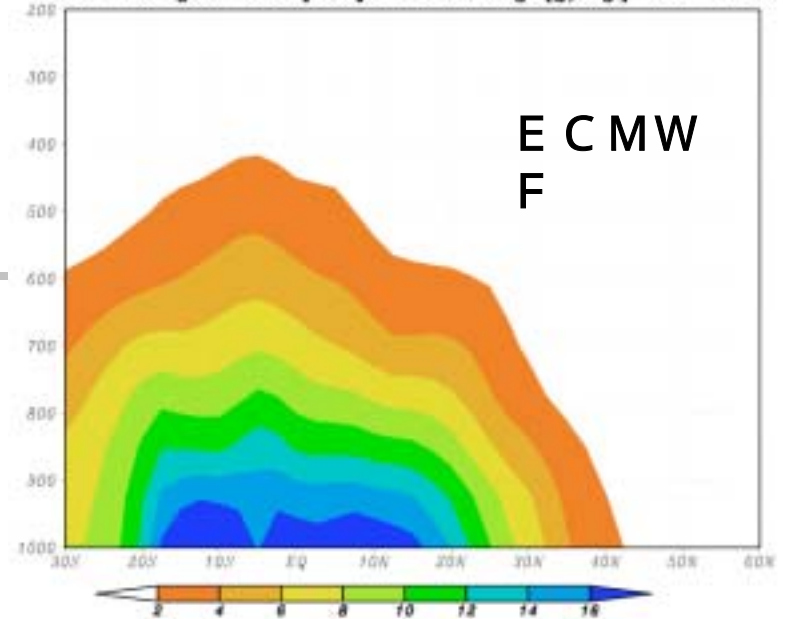
85 - 95 E

Bay of Bengal

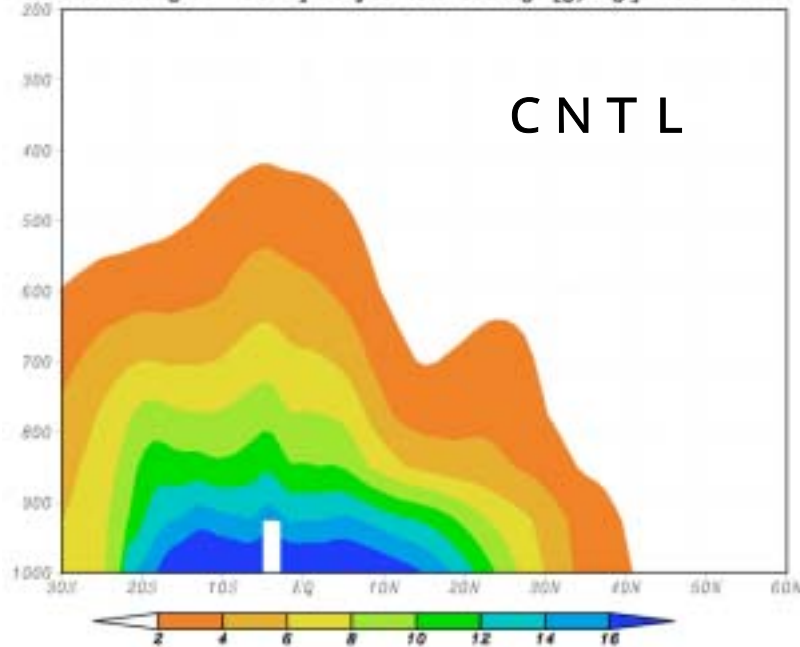
JAN amip y79-98 specific humidity [g/kg] 135-145E



JAN ecm y84-93 specific humidity [g/kg] 135-145E

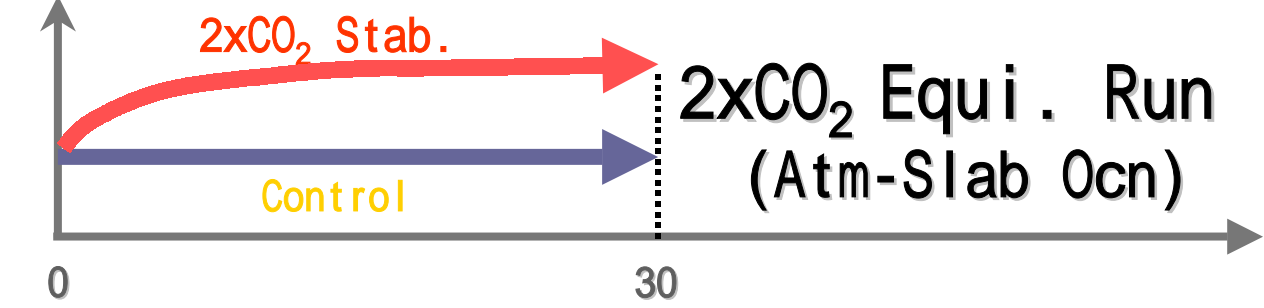
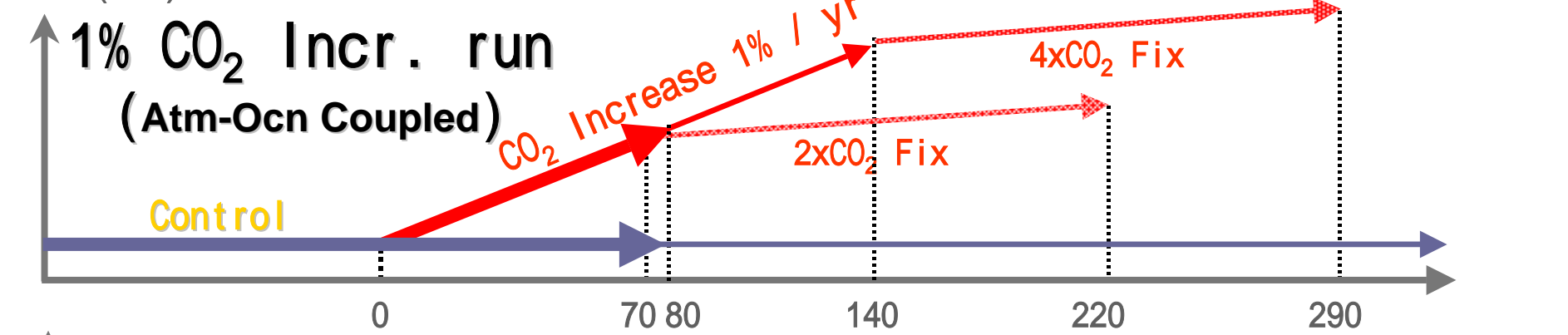
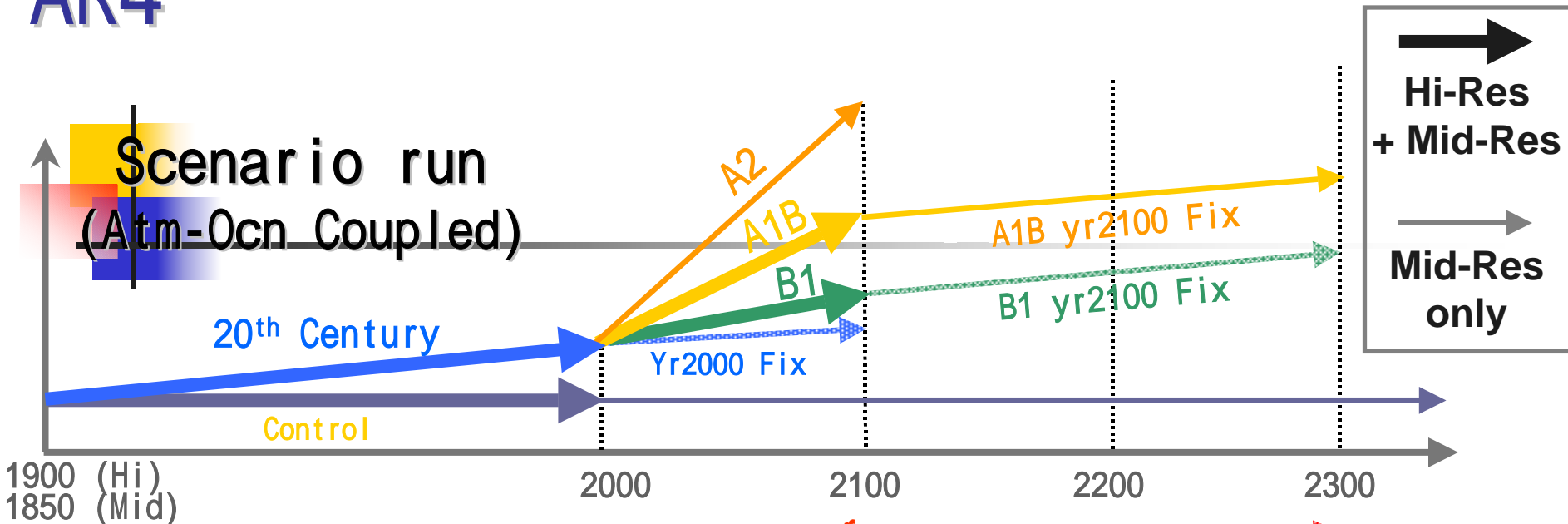


JAN ctl y31-40 specific humidity [g/kg] 135-145E

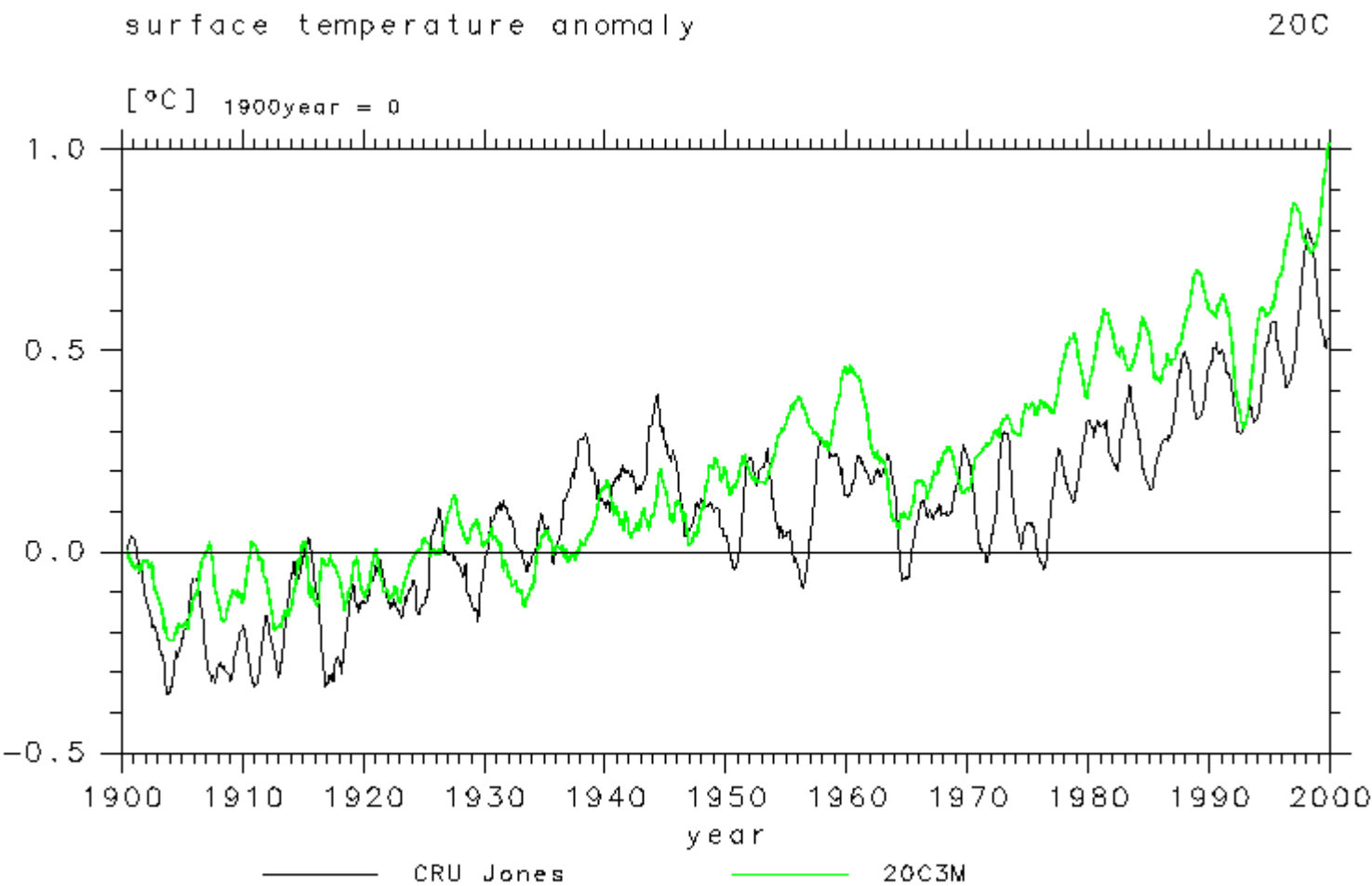


Western
Pacific

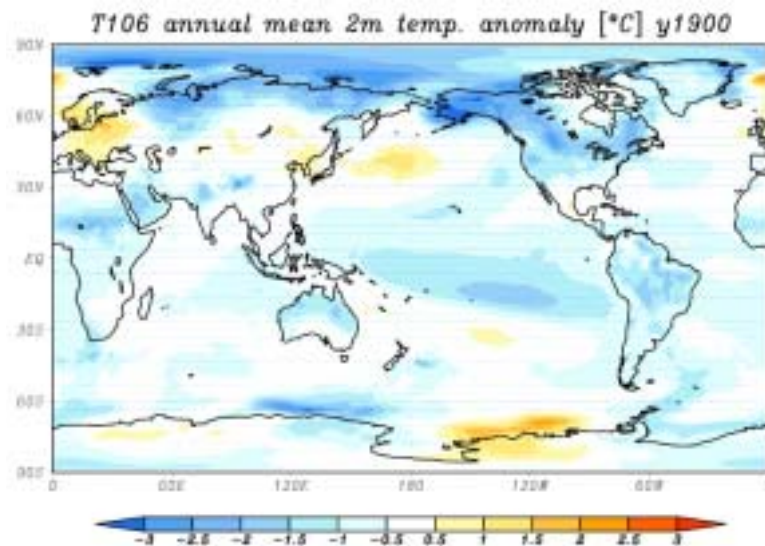
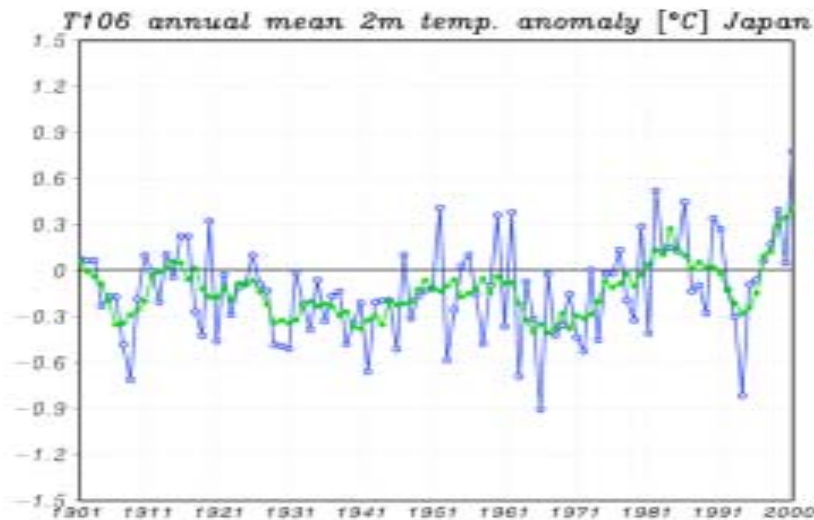
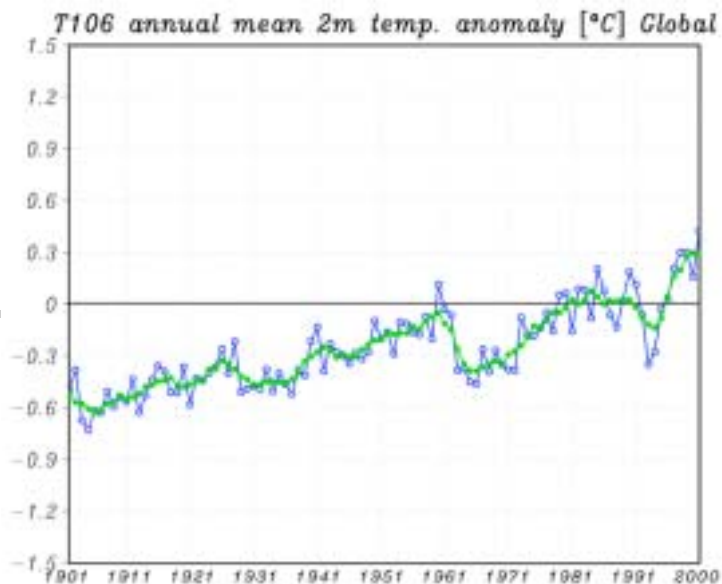
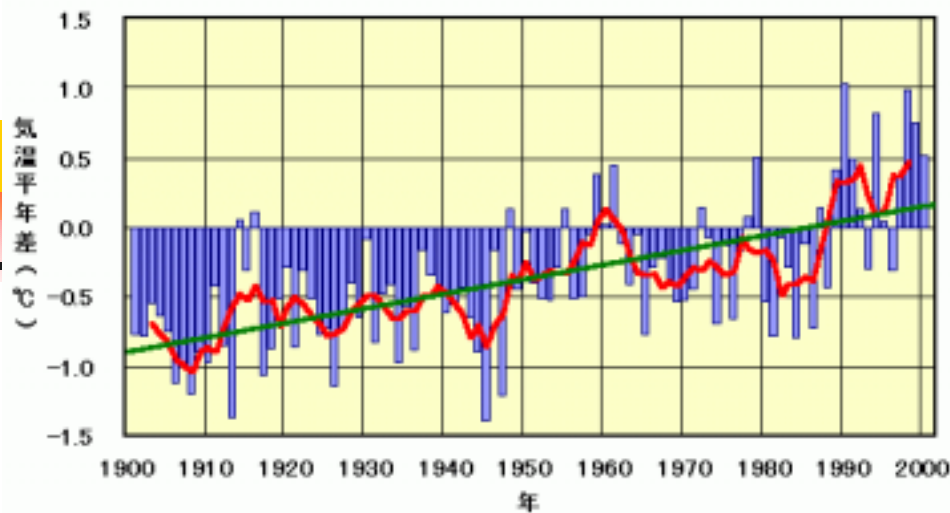
AR4

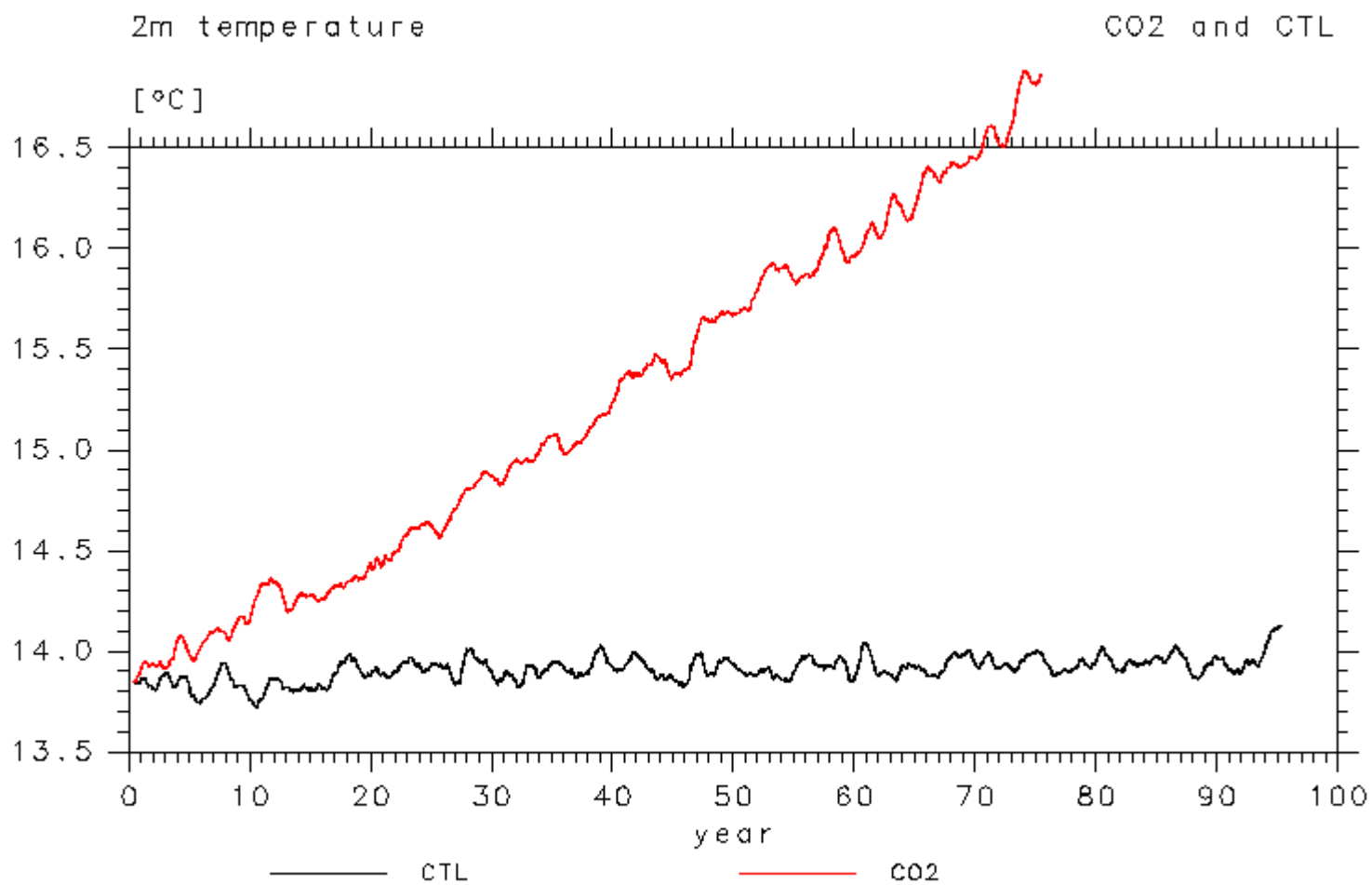


- Model Intercomp. Proj.**
- AMIP (Atmosphere)
 - OMIP (Ocean)
 - CFMIP (Cloud Forcing)



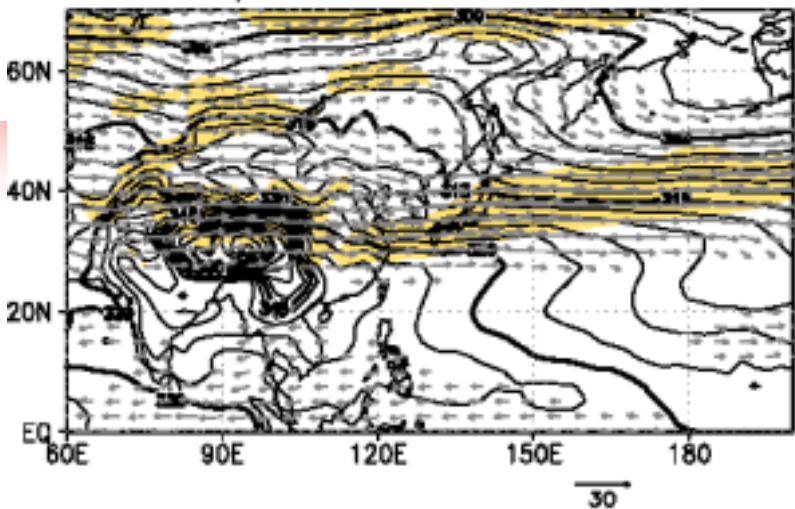
20C3 Run



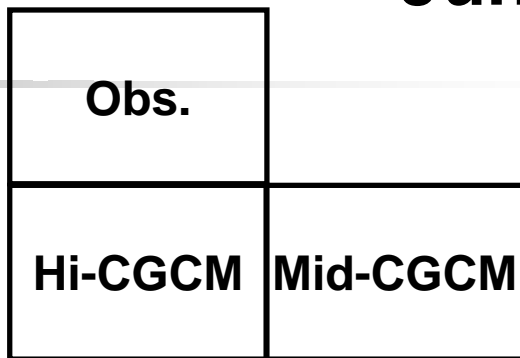


1% CO2 Run

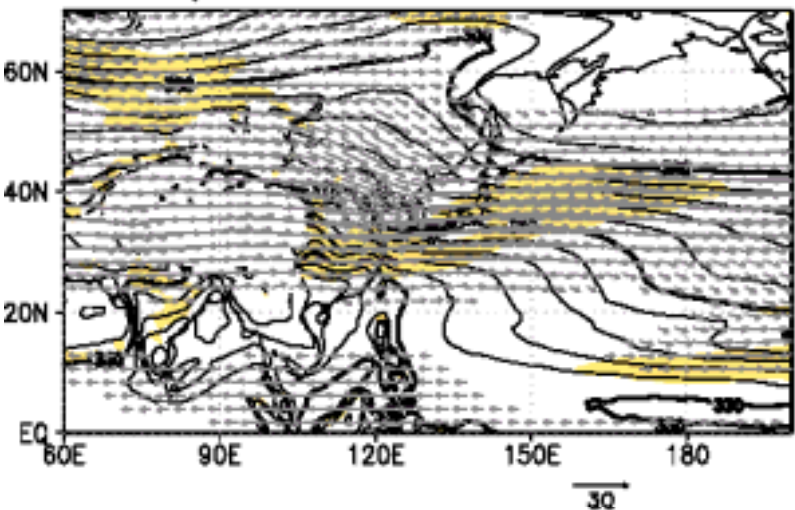
h/V300 1xCO2 Obs. Jun



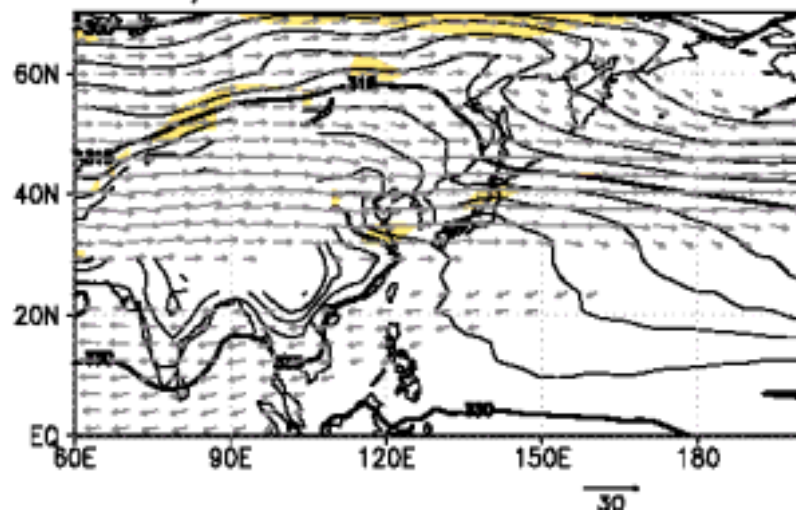
MSE/ _yMSE/V300 June



h/V300 1xCO2 Hi-CGCM Jun

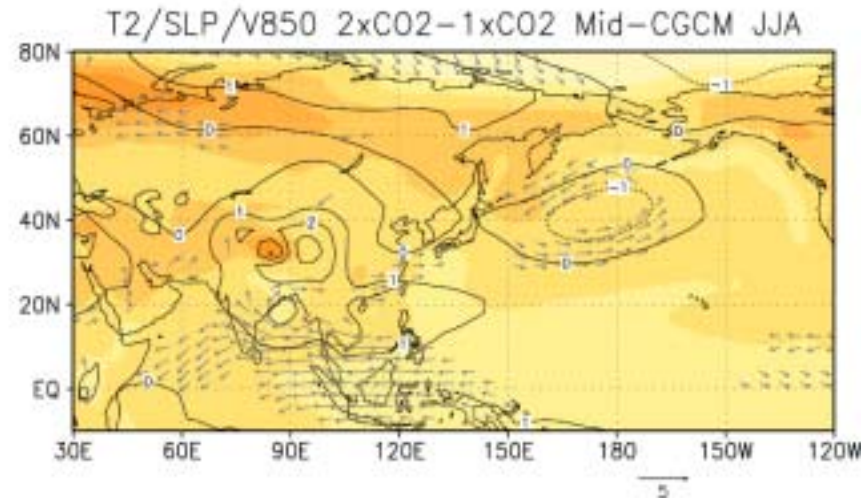
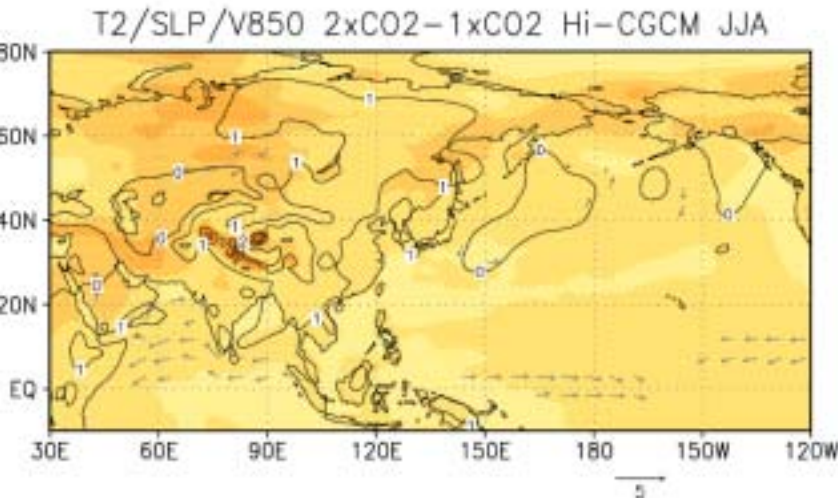
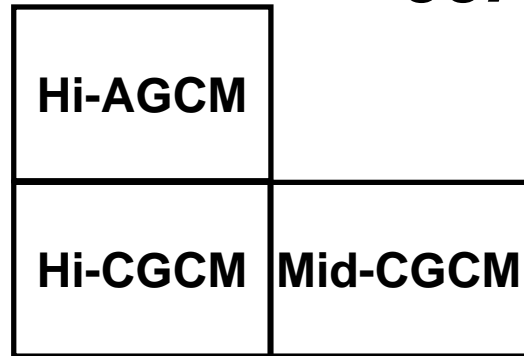
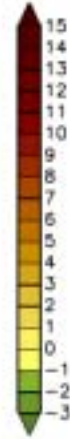
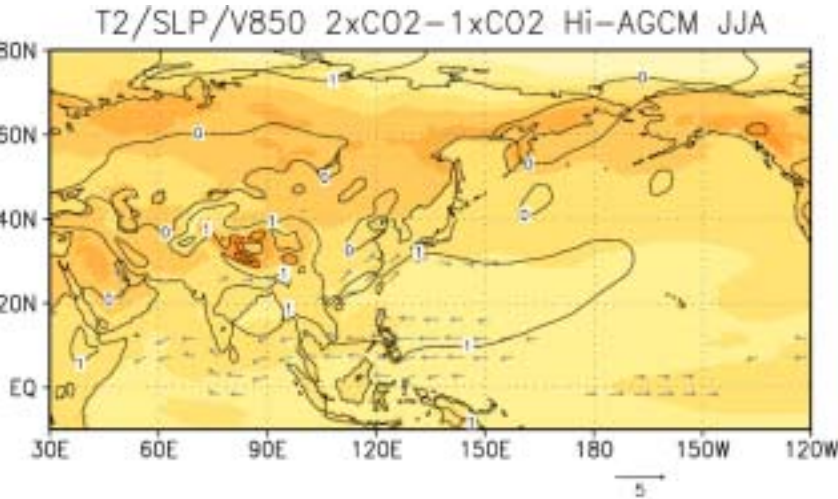


h/V300 1xCO2 Mid-CGCM Jun



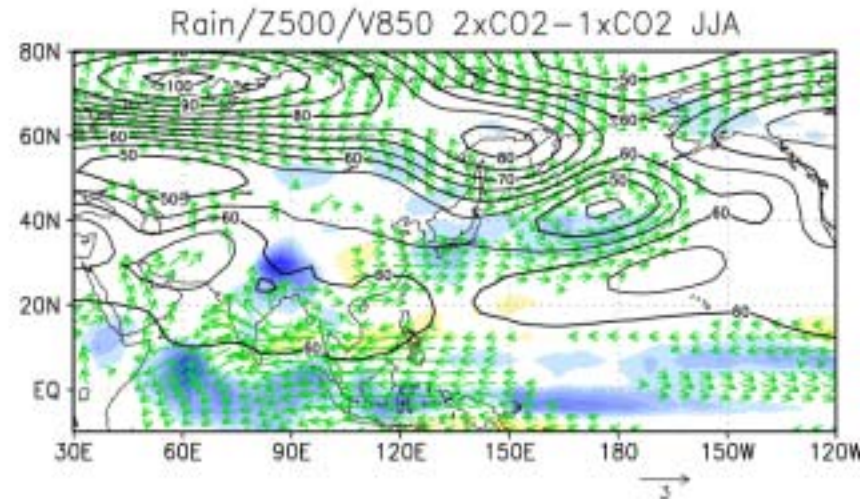
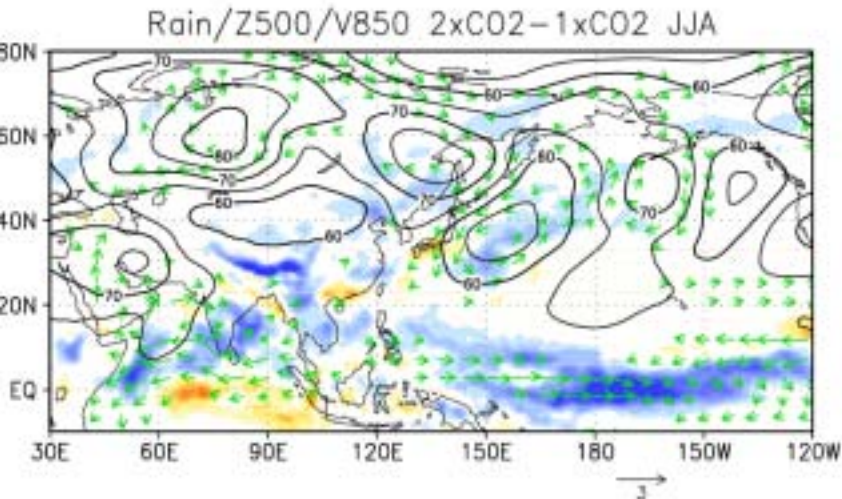
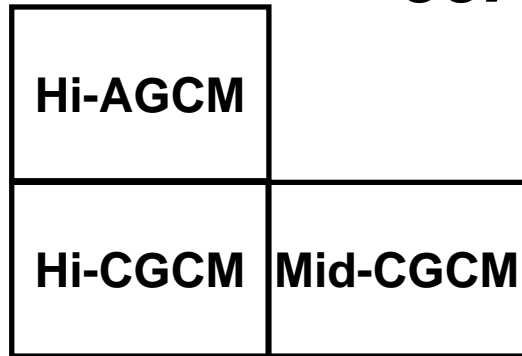
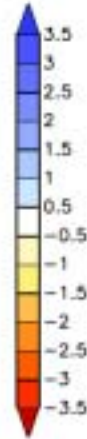
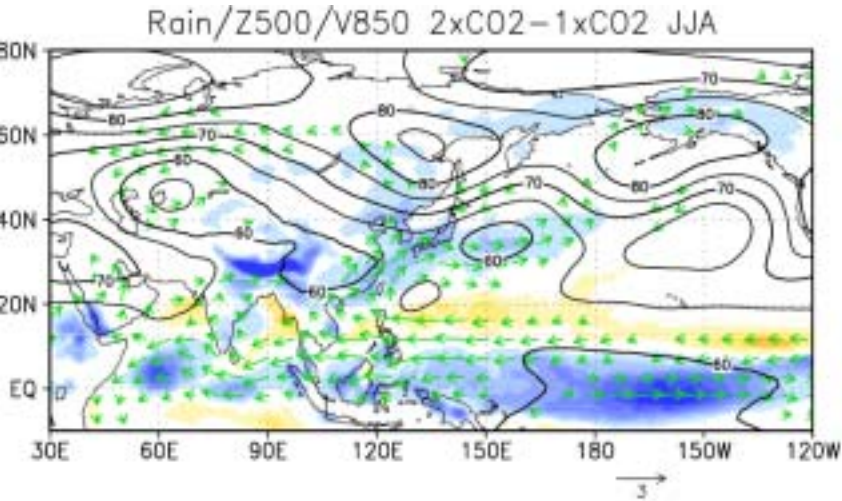
2xCO2-1xCO2

SAT/SLP/V850 JJA



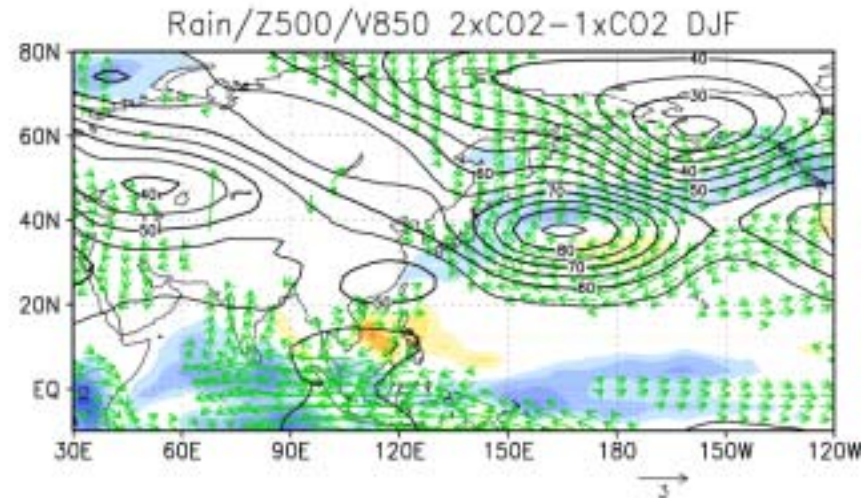
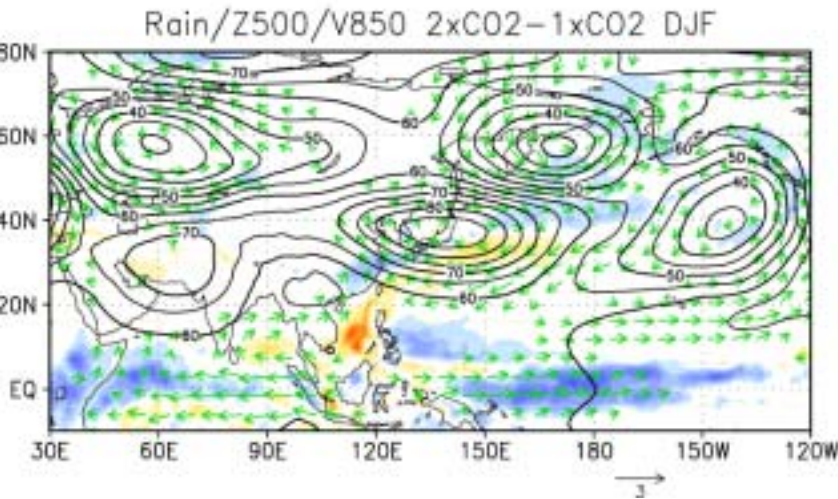
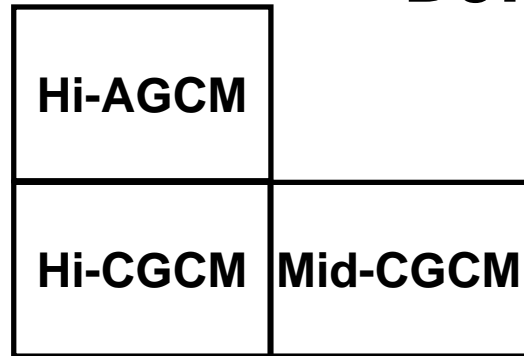
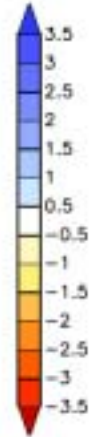
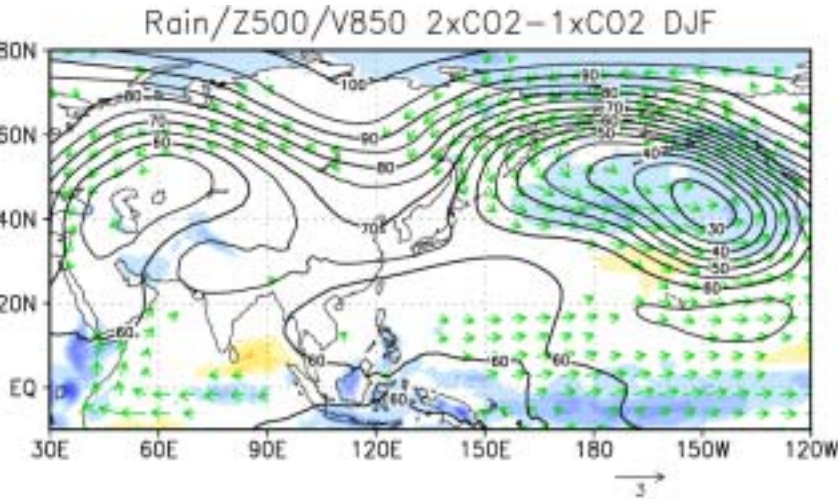
2xCO2-1xCO2

Rain/Z500/V850 JJA



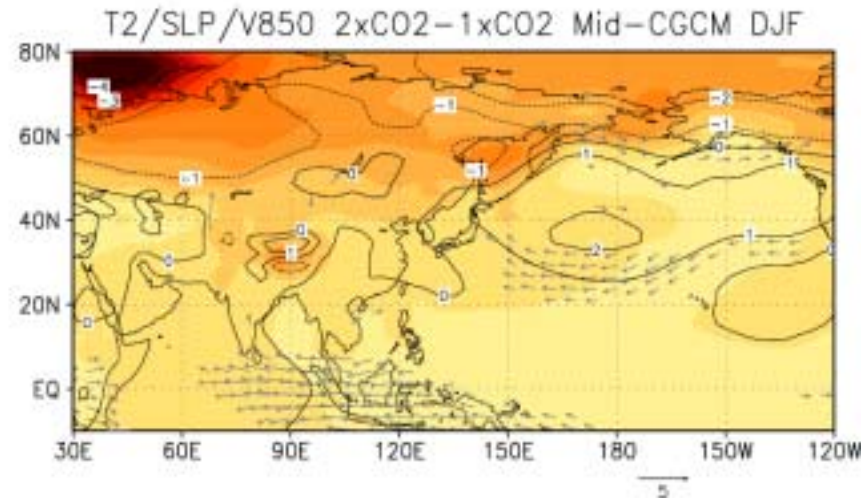
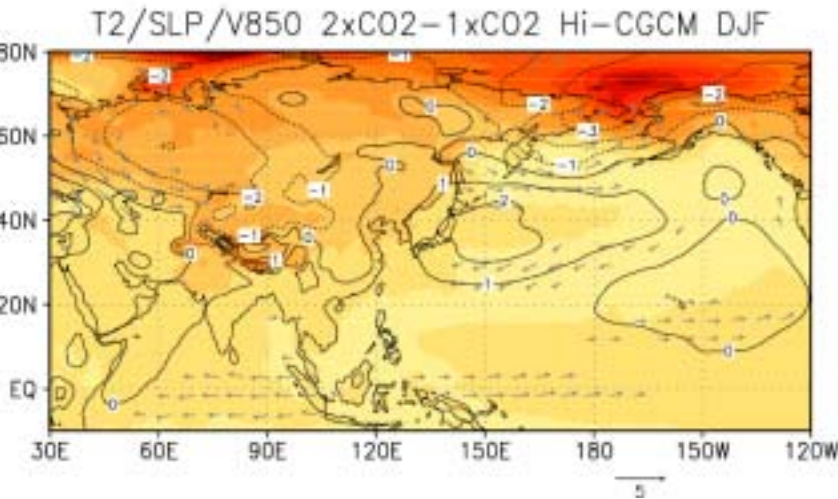
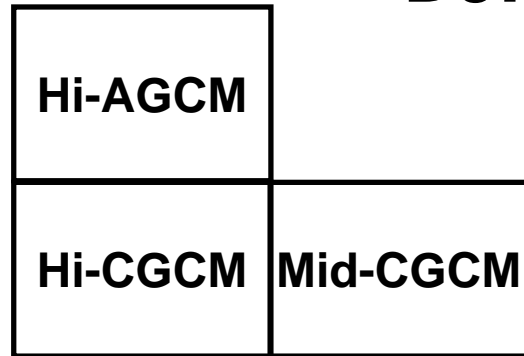
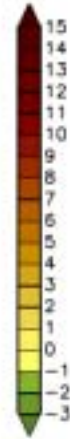
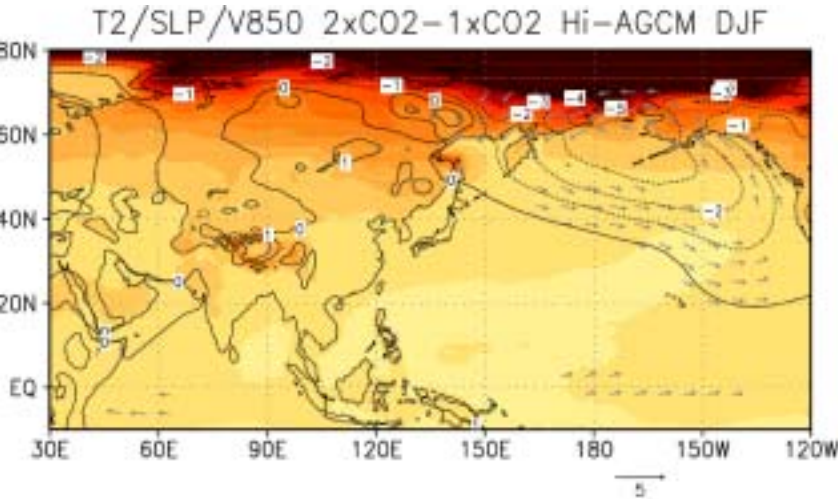
2xCO2-1xCO2

Rain/Z500/V850 DJF

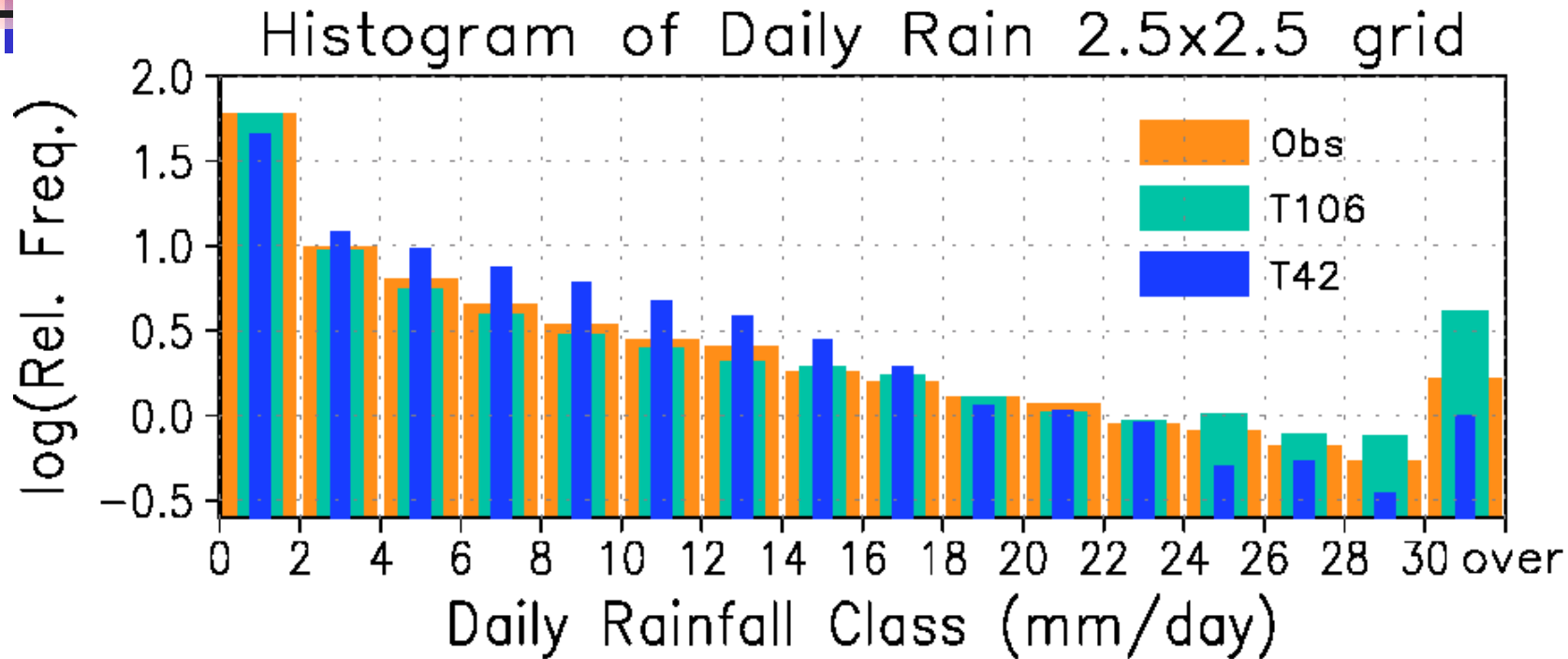


2xCO2-1xCO2

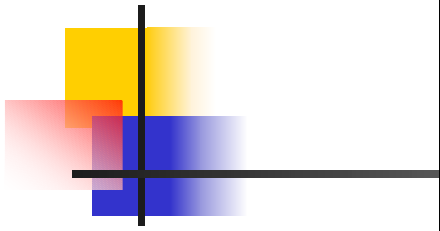
SAT/SLP/V850 DJF



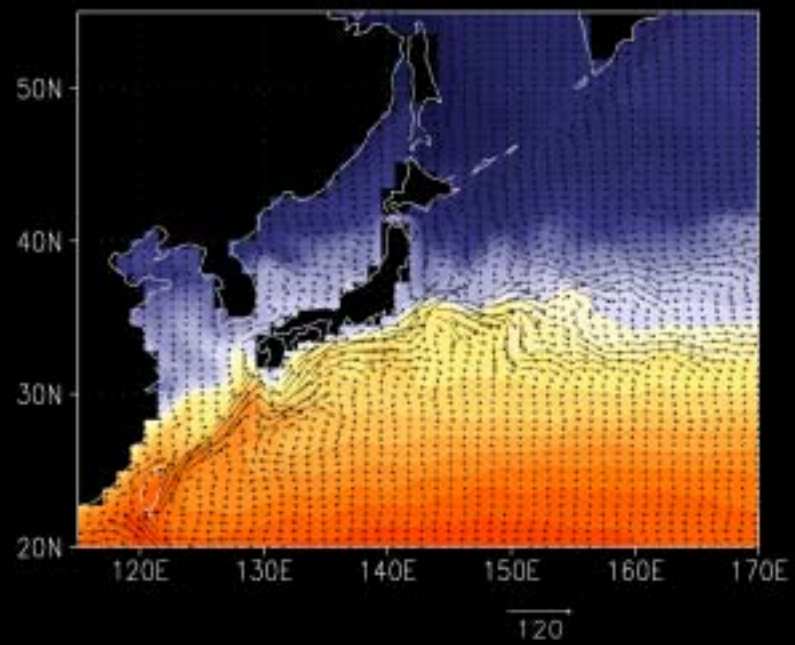
Verification of daily rainfall frequency over Japan (120-140E, 30N-40N)



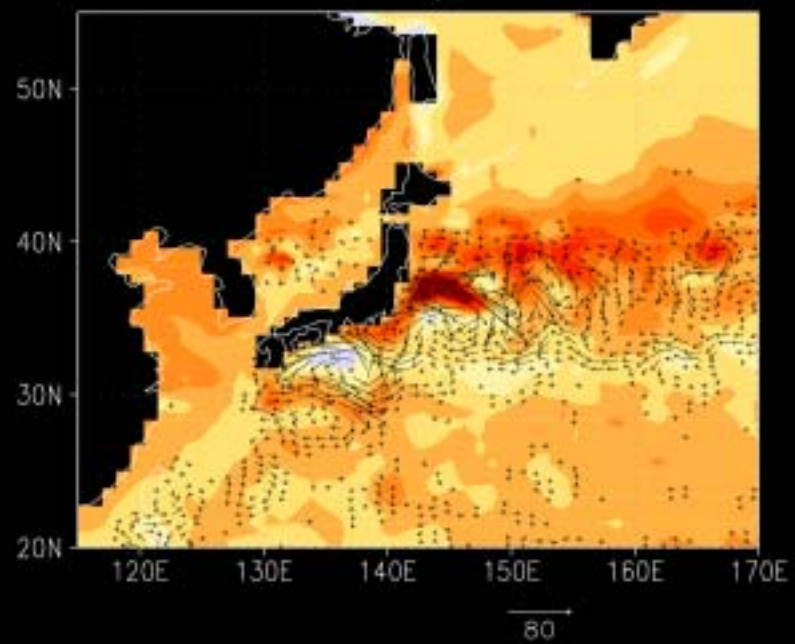
CGCM results



CTL yr61-69

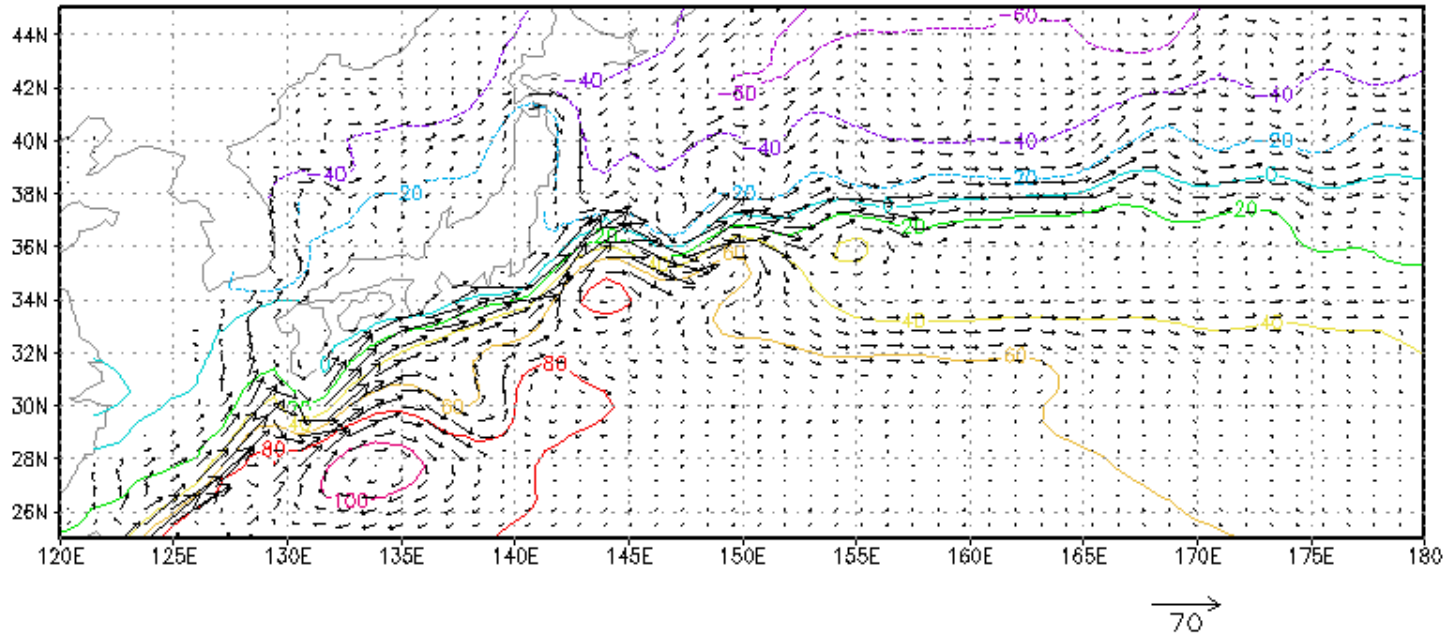


CO2-CTL yr61-69



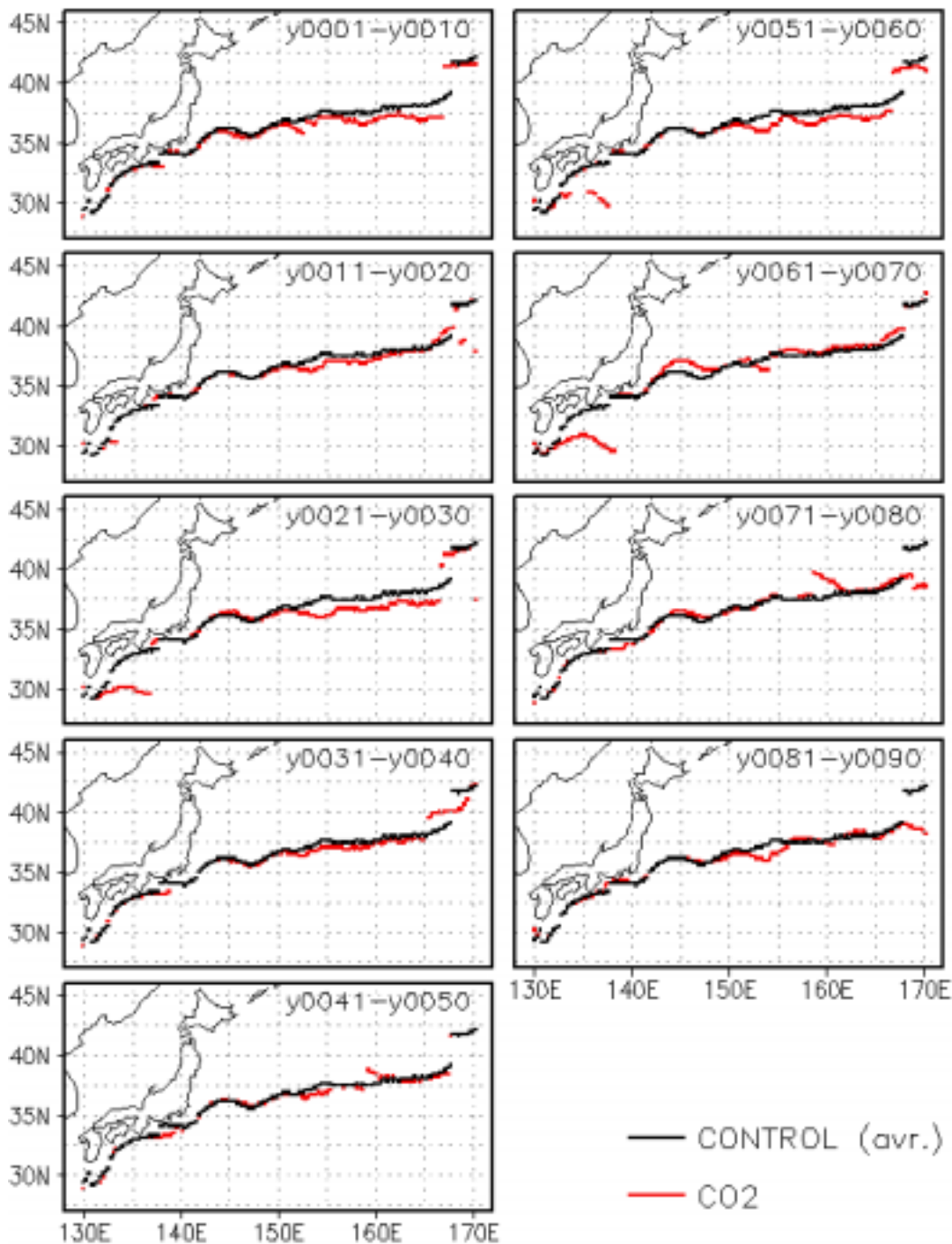
Determination of Kuroshio axis

- South of Japan, 200m-depth, 16degC isotherm is used.
- Maximum of SSH gradient



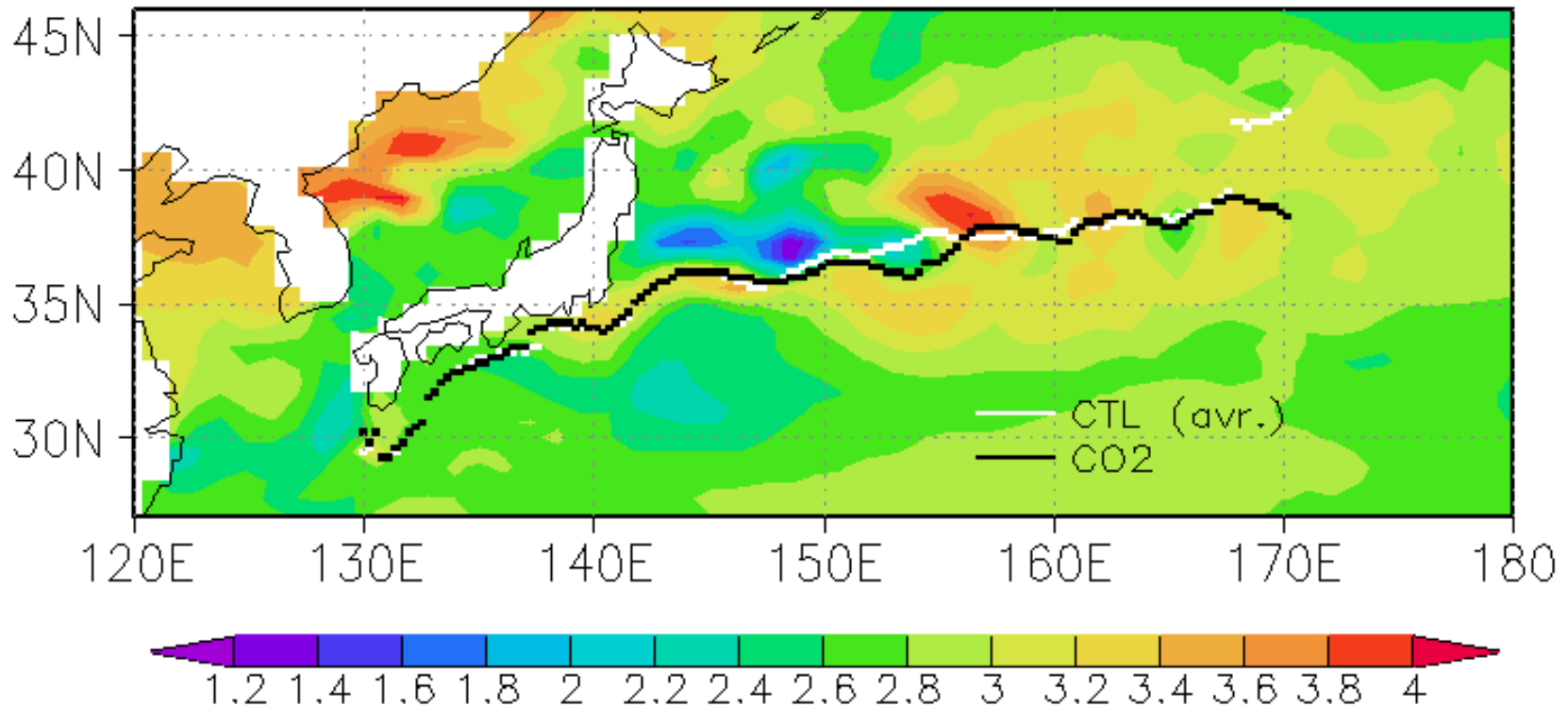
Change of Kuroshio axis

■ No change of Kuroshio axis



(CTLは100年間の平均)

SSTの上昇と流軸?

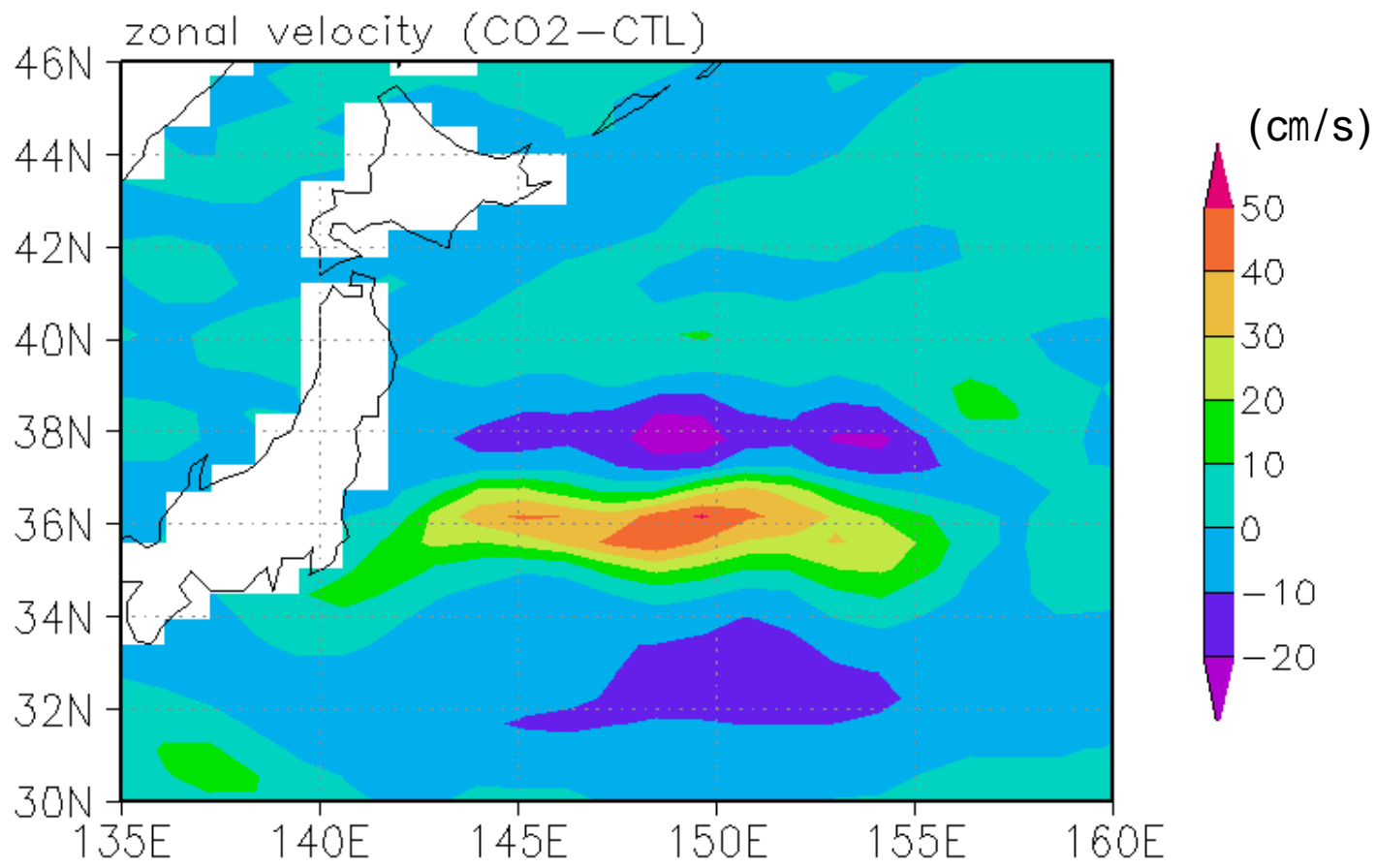
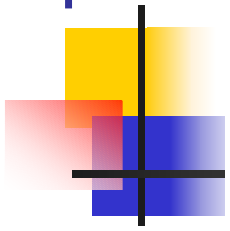


■ Temperature Change is large along the Kuroshio axis

以降CO₂-CTLと表記する場合はCO₂ 1% 漸
Control の100年間の平均の差とする

の81-90年目の平均と

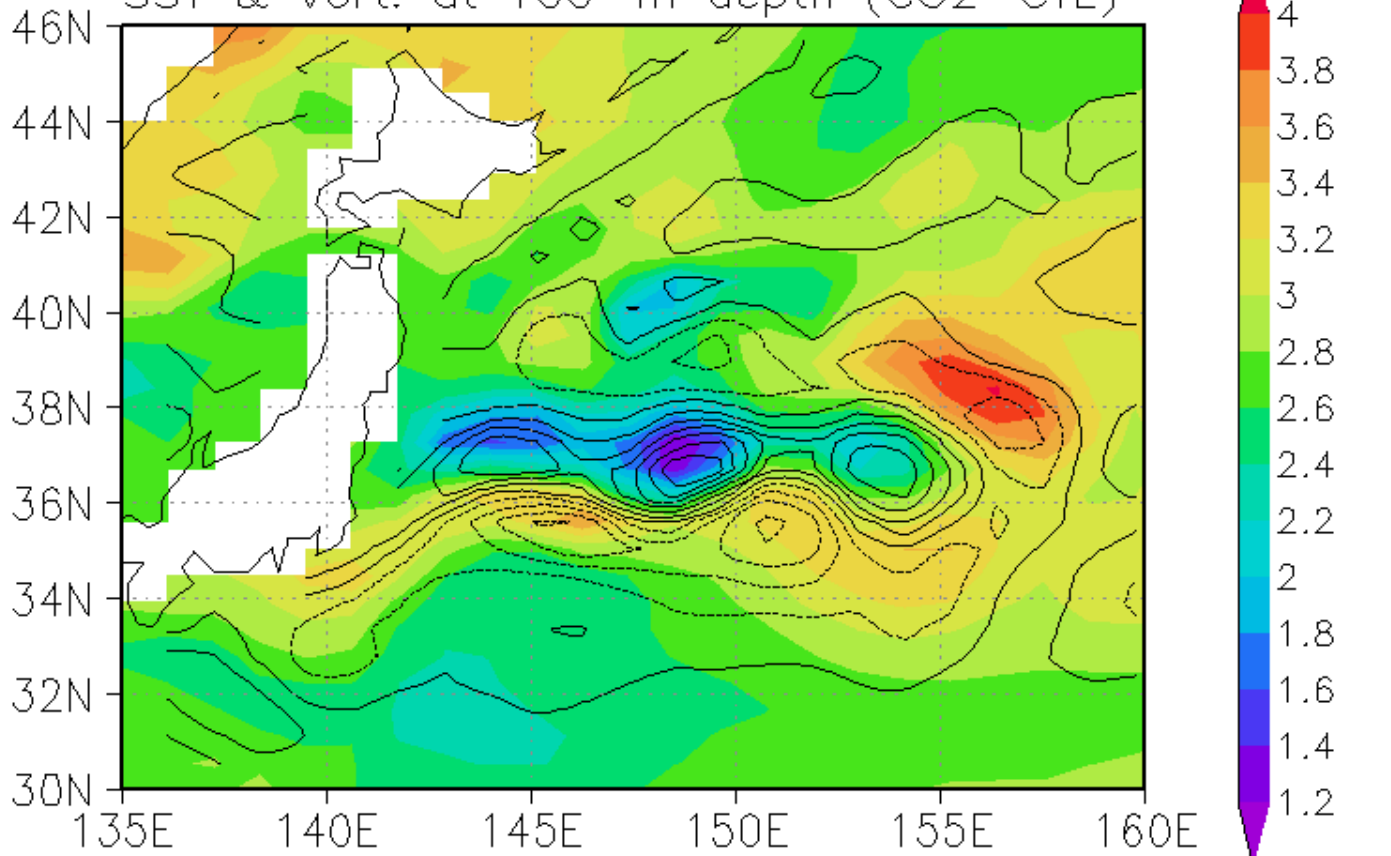
ifference of East-west current at 100m epth



- Current speed is increased due to the warming

流速の 加に伴う渦度

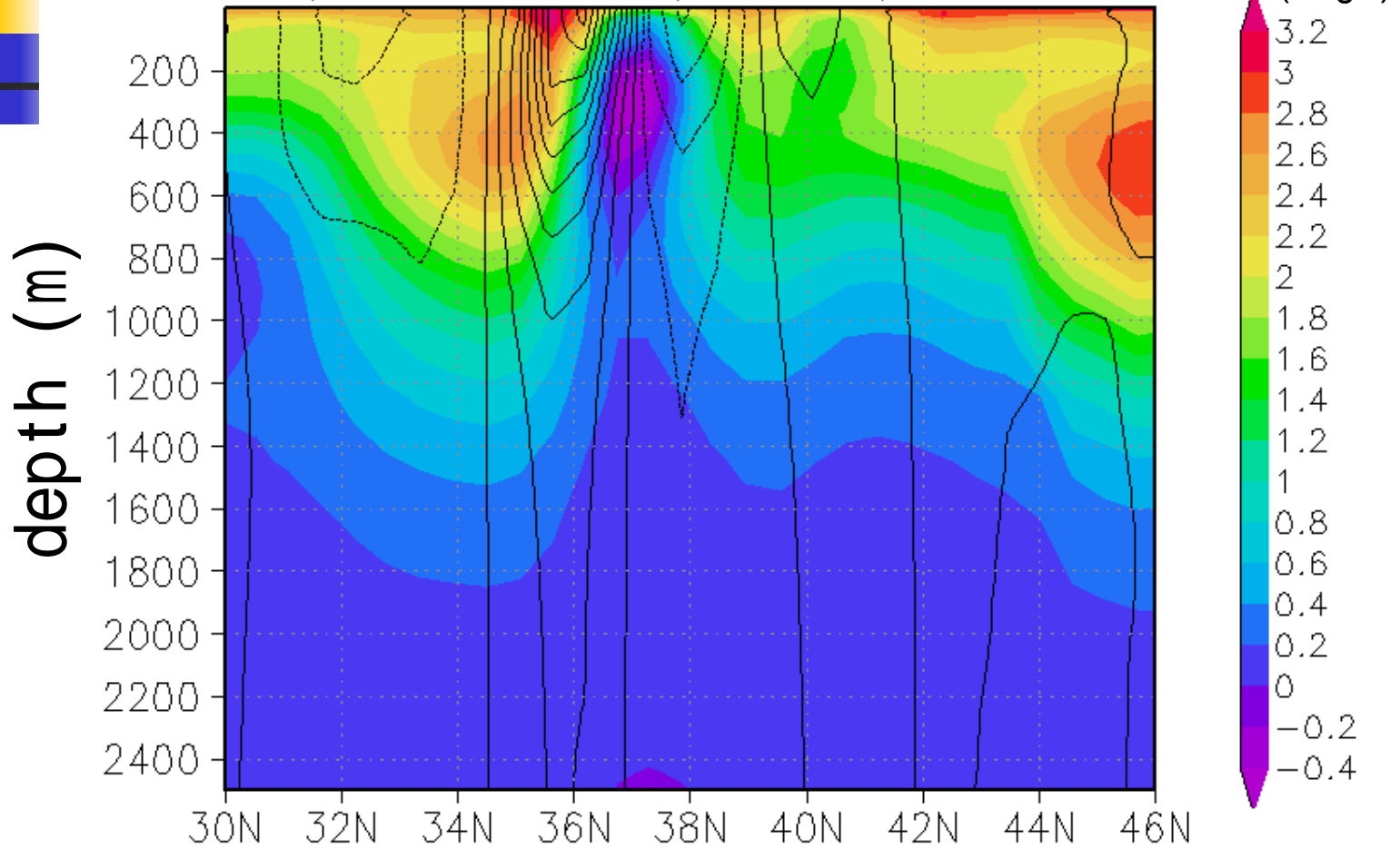
SST & vort. at 100-m depth (CO2-CTL)



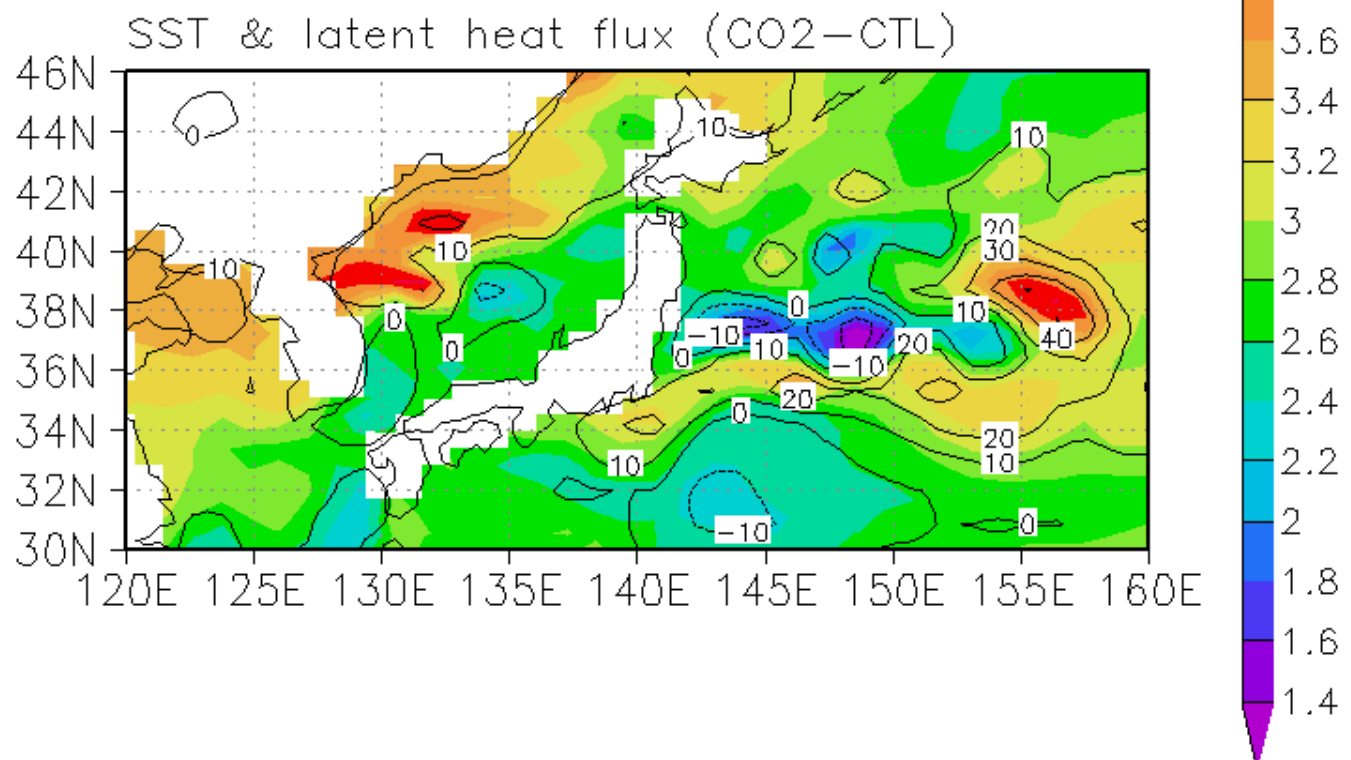
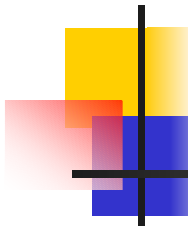
- 負の渦度：高 性渦、 $d(SST)$ 大
- 正の渦度：低 性渦、 $d(SST)$ 小

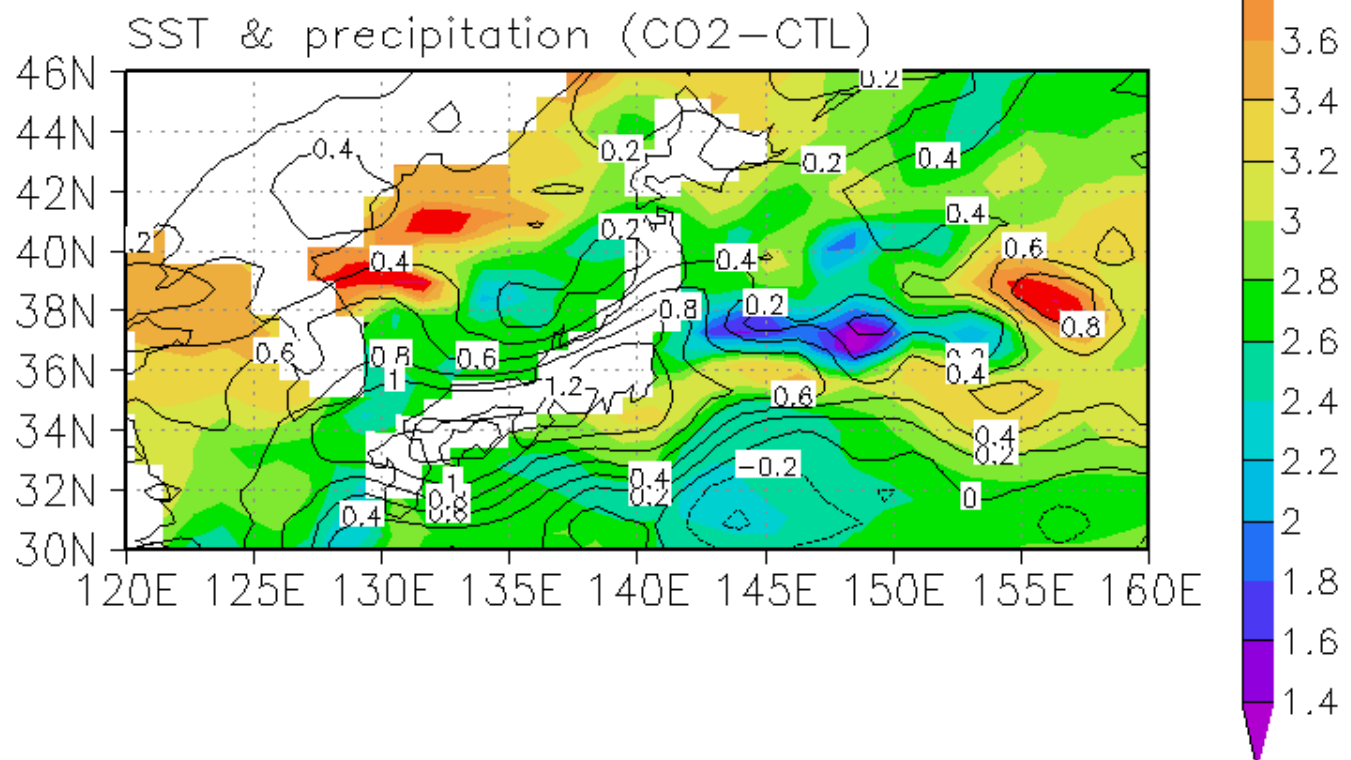
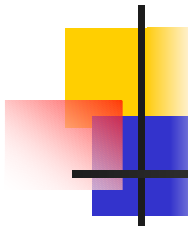
海水、東西流速の y-z 面

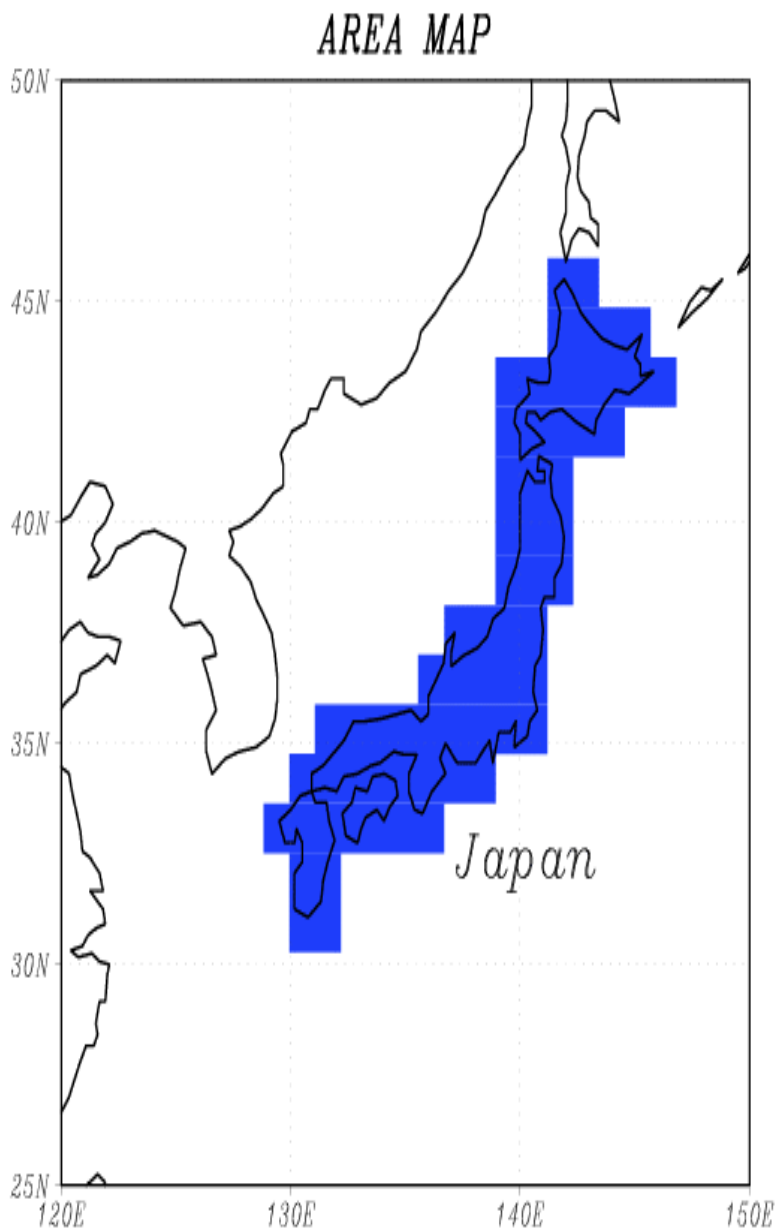
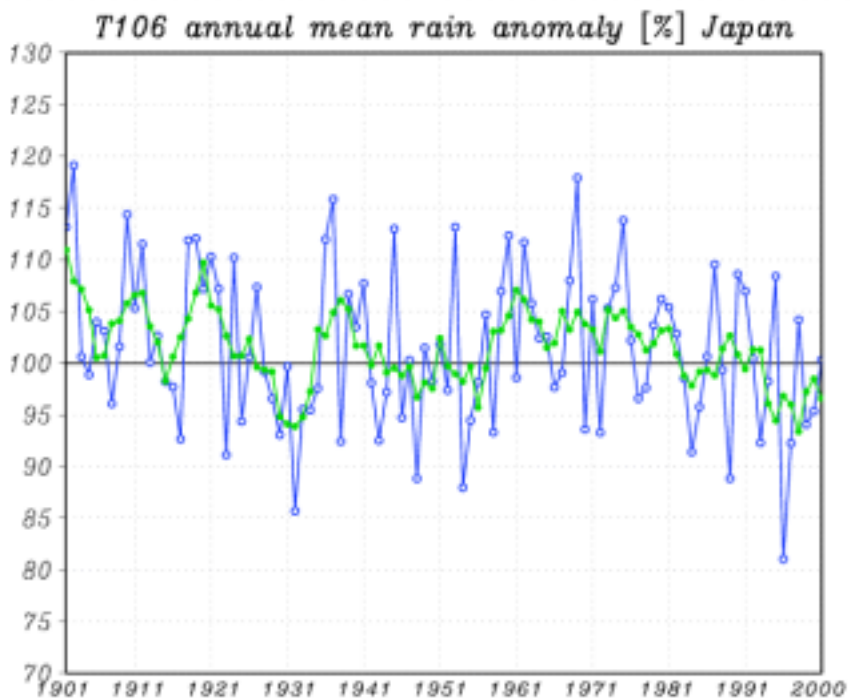
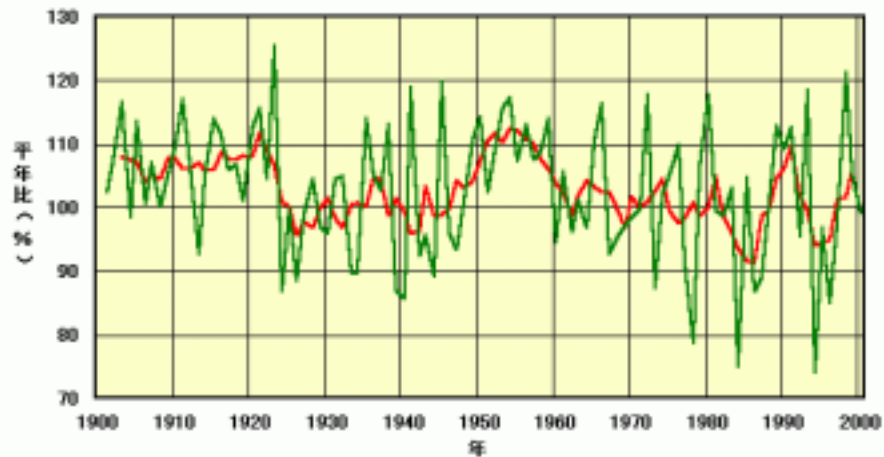
temp. & zonal vel. (CO2-CTL)



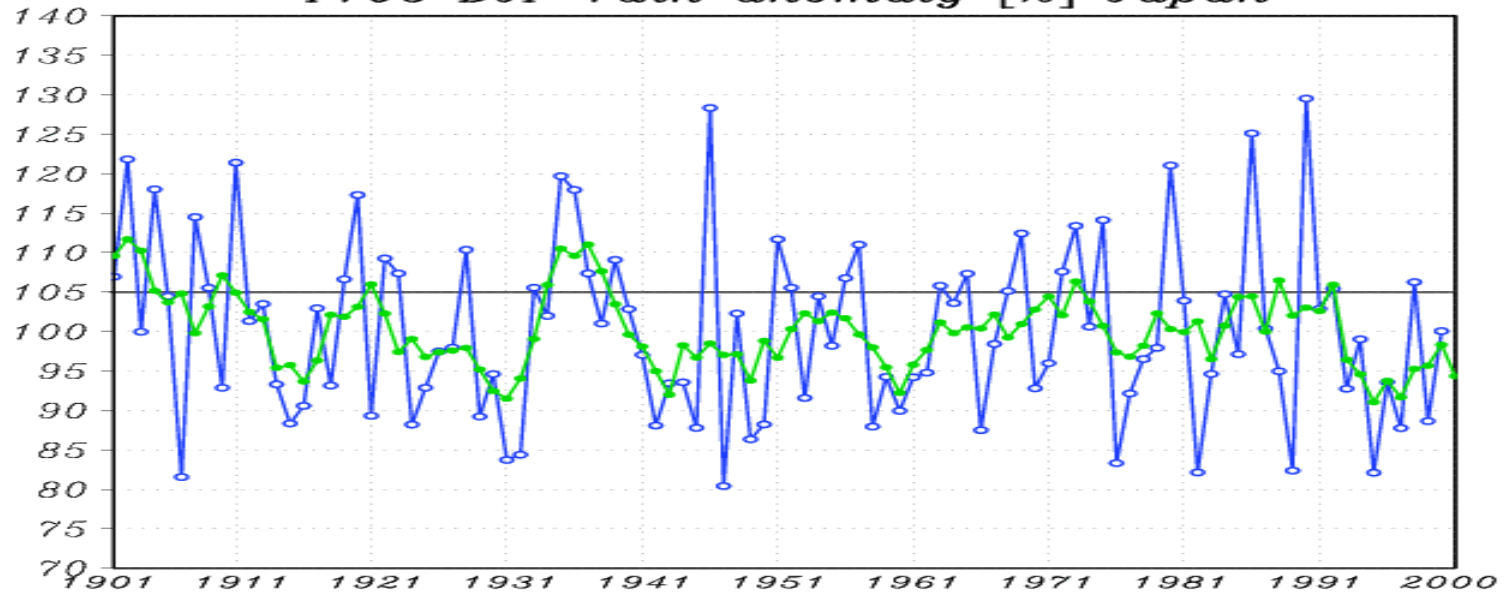
(145-E150E の平均)



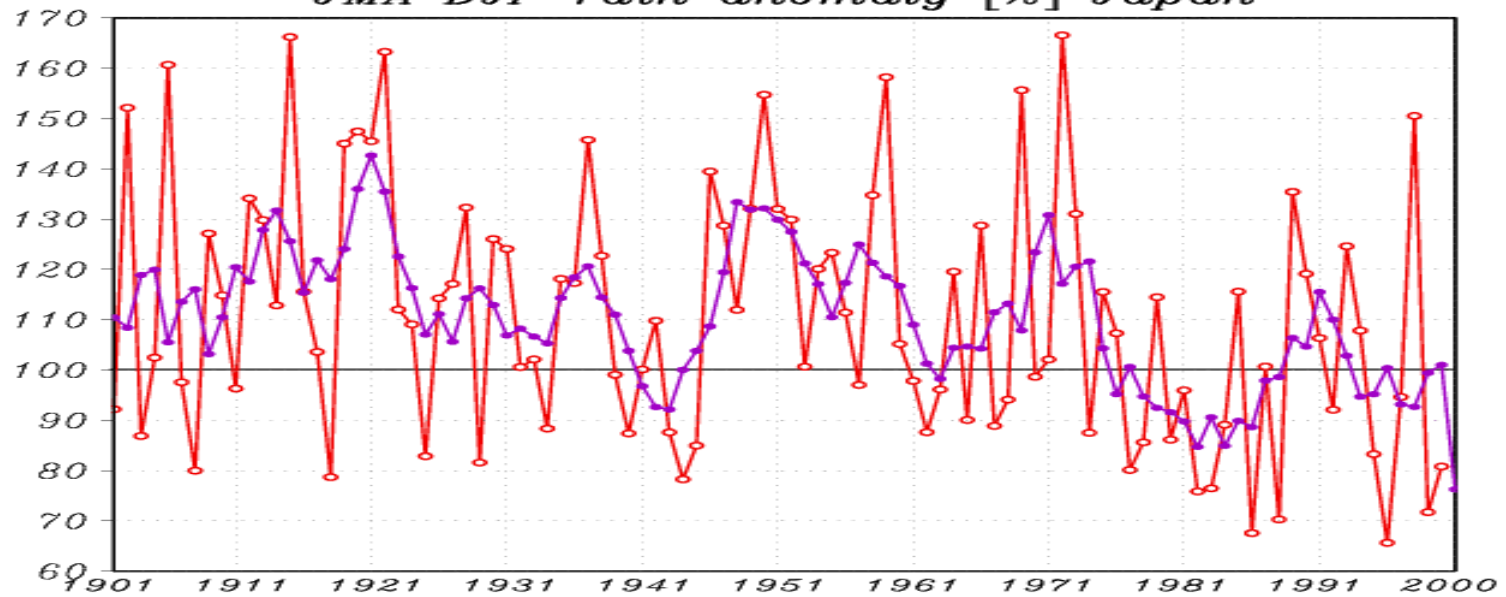




T106 DJF rain anomaly [%] Japan



JMA DJF rain anomaly [%] Japan





Summary

- The K-1 climate model shows a reasonably good performance.
- Decadal-scale variability is well reproduced.
- Regional climate change can be discussed.
- 20C3 simulation suggests that warming after 80s may be due to CO₂ increase.