PICES XIV (2005) in Vladivostok

Present and future of the North Pacific simulated by a high resolution coupled atmosphere-ocean model

Hiroyasu HASUMI (CCSR)
Tatsuo SUZUKI (FRCGC)
Takashi SAKAMOTO (FRCGC)
Seita EMORI (NIES)
Masahide KIMOTO (CCSR)
Akimasa SUMI (CCSR)

Japan K-1 Project Team

Research consortium of

- -Center for Climate System Research (CCSR), the University of Tokyo
- -National Institute for Environmental Studies (NIES)
- -Frontier Research Center for Global Change (FRCGC)

for global warming projections by using a high resolution atmosphere-ocean model,

under the government-funded "Project for Sustainable Coexistence of Human, Nature and the Earth."

Coupled GCM

MIROC (Model for Interdisciplinary Research On Climate) version 3.2

Atmosphere: CCSR/ NIES/FRCGC AGCM 5.7		
Ocean: CCSR Ocean Component Model 3.4		
Land: MATSIRO		
River: TRIP		
Sea ice: dynamic (EVP)-thermodynamic (0-layer)		

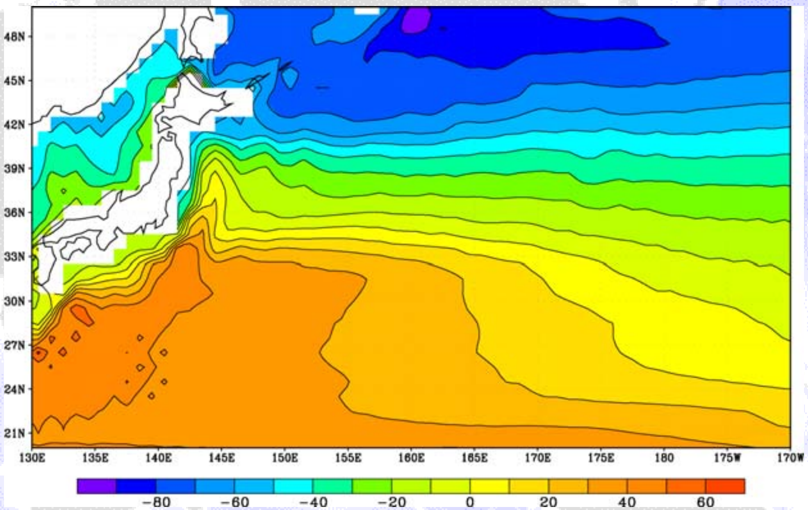
Coupled GCM

MIROC (Model for Interdisciplinary Research On Climate) version 3.2

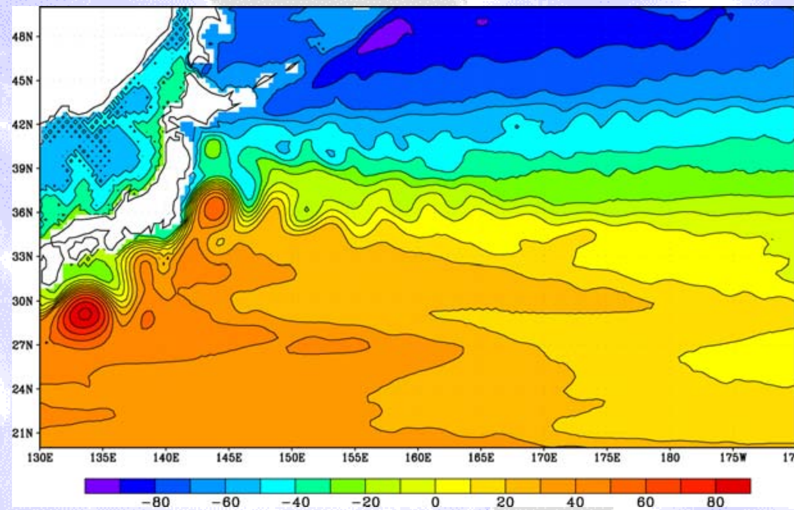
	High	
Atmosphere: CCSR/ NIES/FRCGC AGCM 5.7	T106 (~1.1°) 50 levels	
Ocean: CCSR Ocean Component Model 3.4	~0.28°x0.19° 47 levels	
Land: MATSIRO	~0.56°	
River: TRIP	0.5°	
Sea ice: dynamic (EVP)-thermodynamic (0-layer)	same as ocean	

Coupled GCM

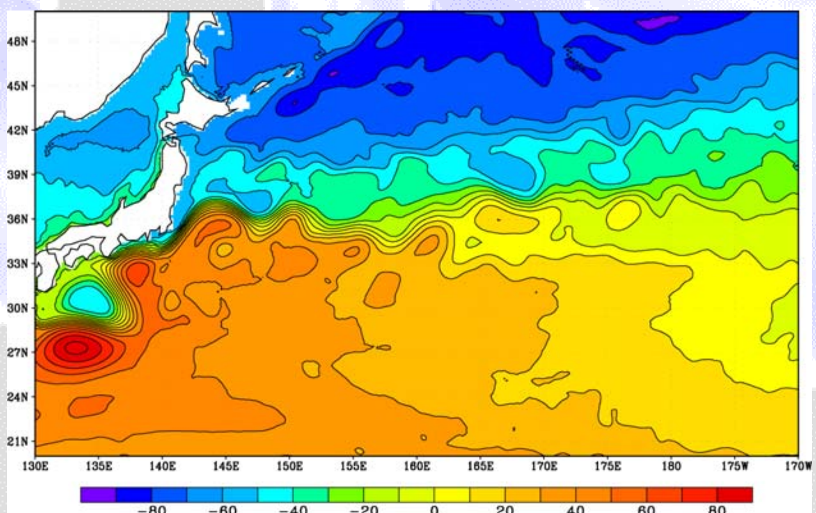
Resolution dependence of Kuroshio separation (sea surface height snapshot)



1x1 deg



1/3x1/3 deg



1/4x1/6 deg

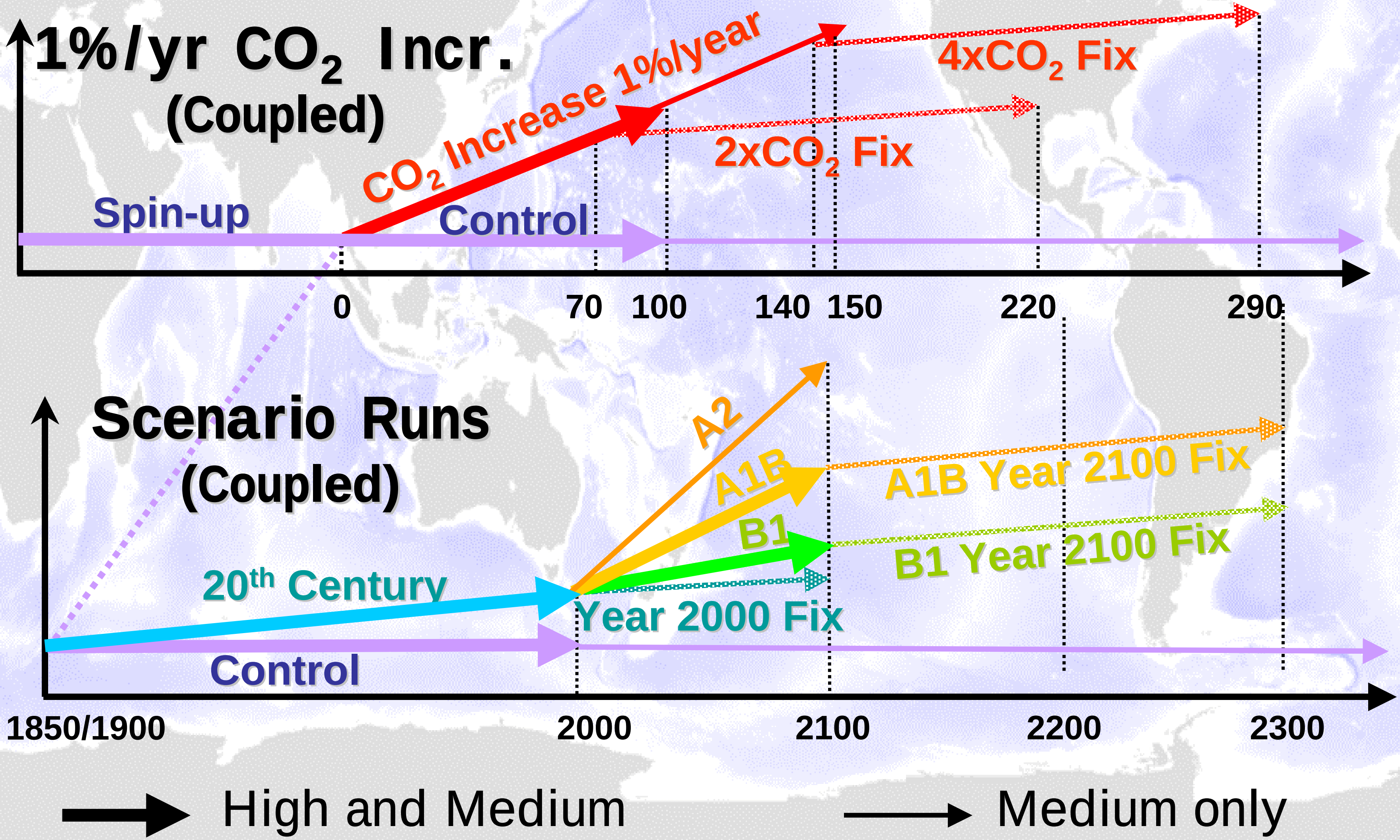
Coupled GCM

MIROC (Model for Interdisciplinary Research On Climate) version 3.2

	High	Medium
Atmosphere: CCSR/ NIES/FRCGC AGCM 5.7	T106 (~1.1°) 50 levels	T42 (~2.8°) 20 levels
Ocean: CCSR Ocean Component Model 3.4	~0.28°x0.19° 47 levels	~1.4°x0.5°-1.4° 43 levels
Land: MATSIRO	~0.56°	~2.8°
River: TRIP	0.5°	~2.8°
Sea ice: dynamic (EVP)-thermodynamic (0-layer)	same as ocean	same as ocean

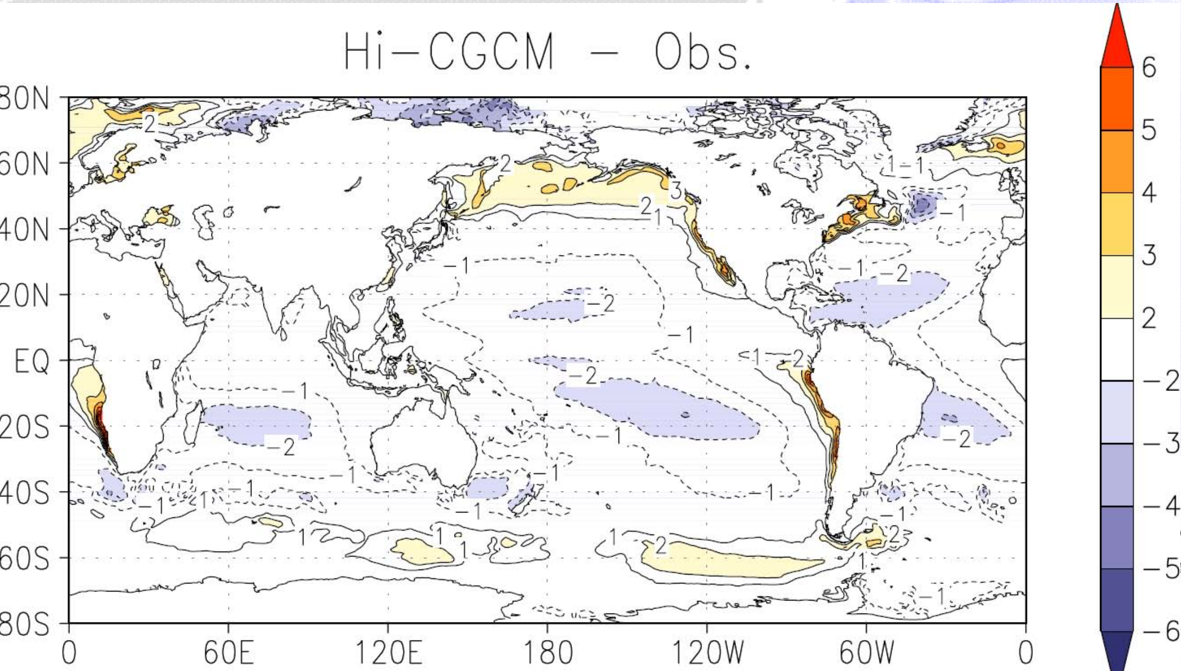
Experiments

Runs for IPCC AR4 and CMIP Coordinated Ex.

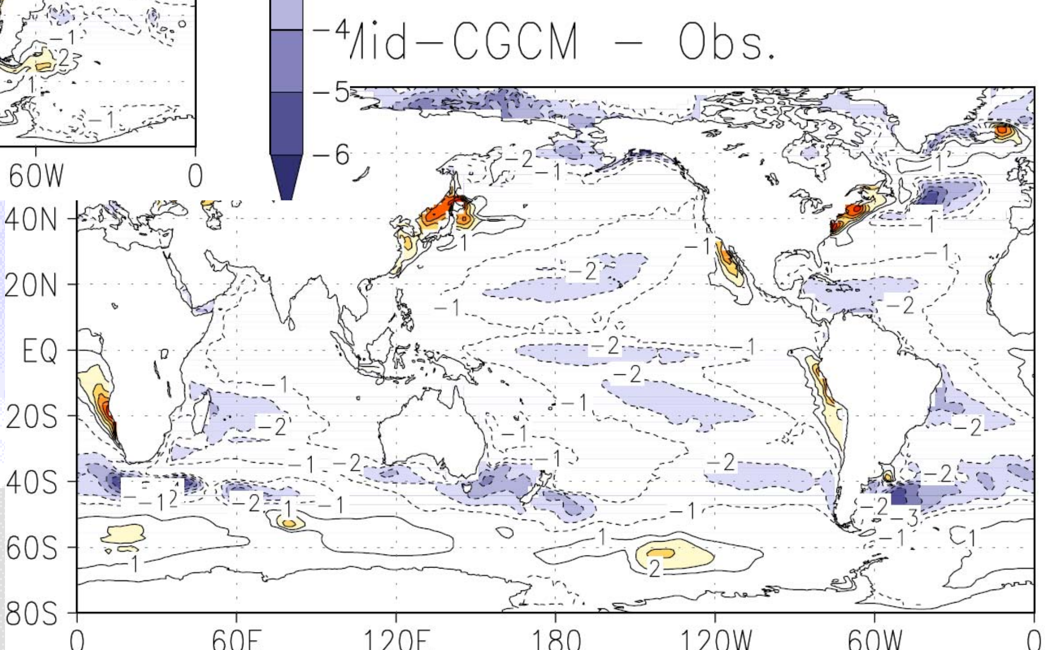


Overall performance of the model

Biases in annual-mean SST of the control run



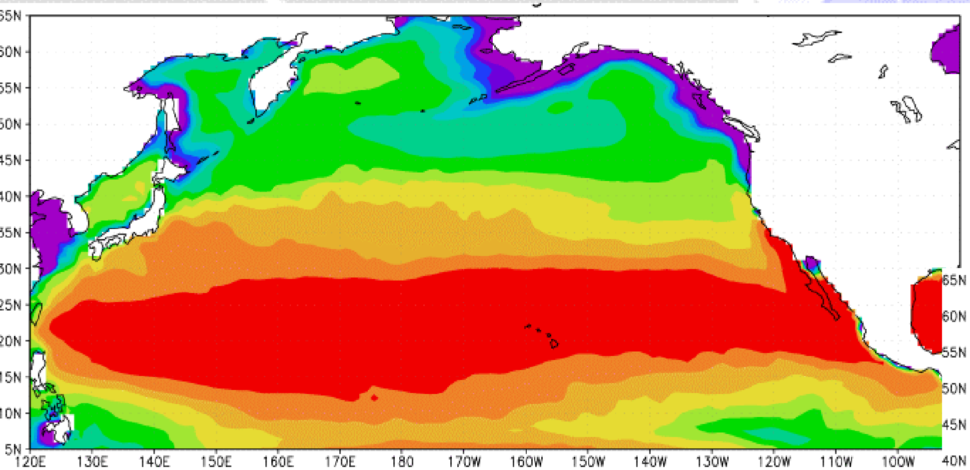
Medium-res.



High-res.

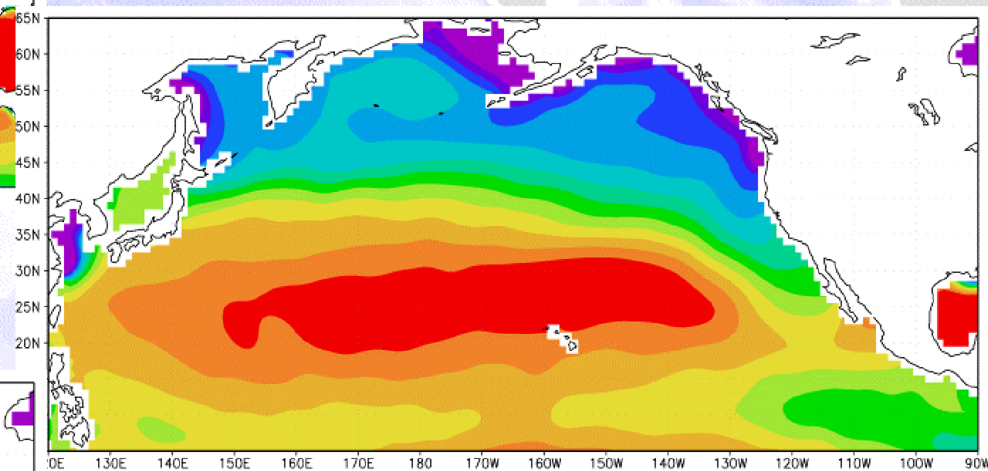
Overall performance of the model

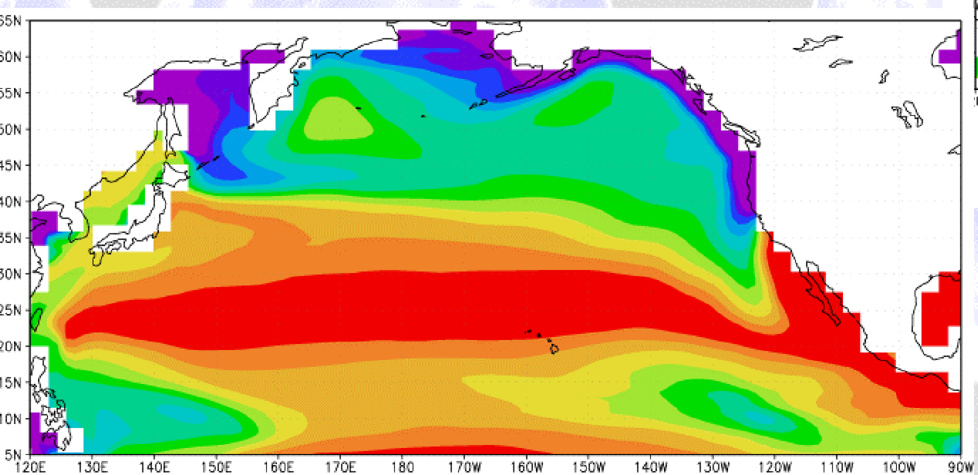
Annual mean SSS



High-res. CONTROL

WOA01

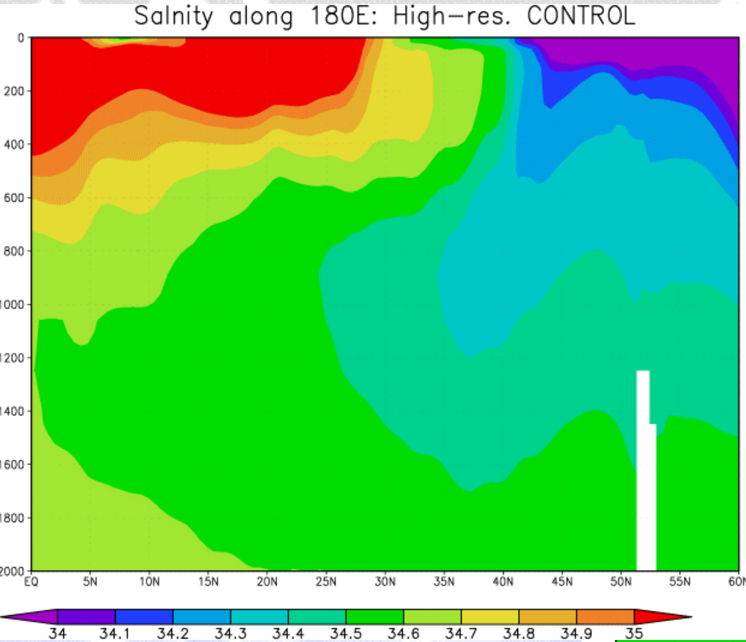




Medium-res. CONTROL

Overall performance of the model

Salinity along 180E (NPIW)



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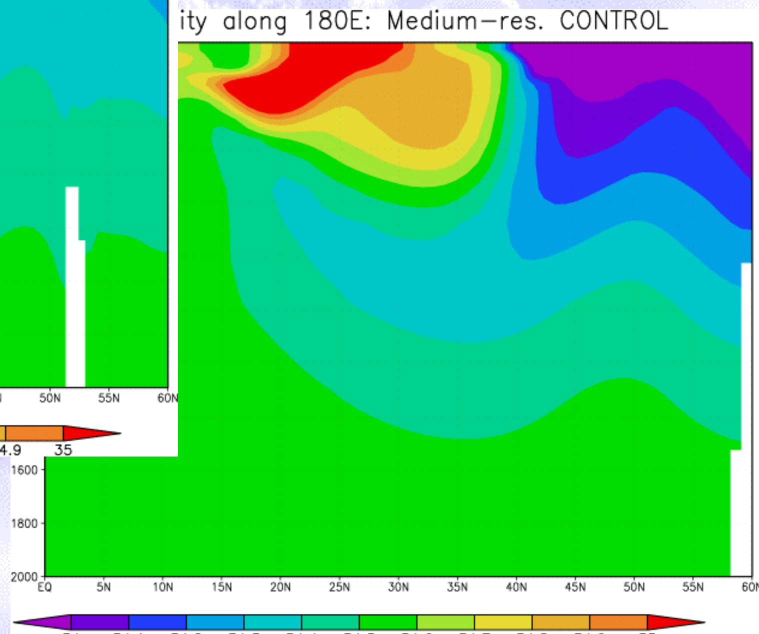

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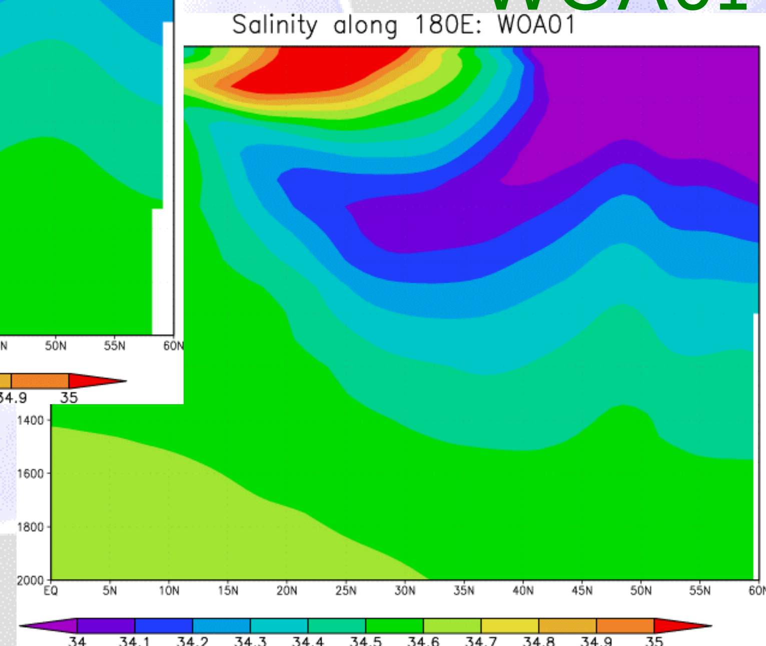
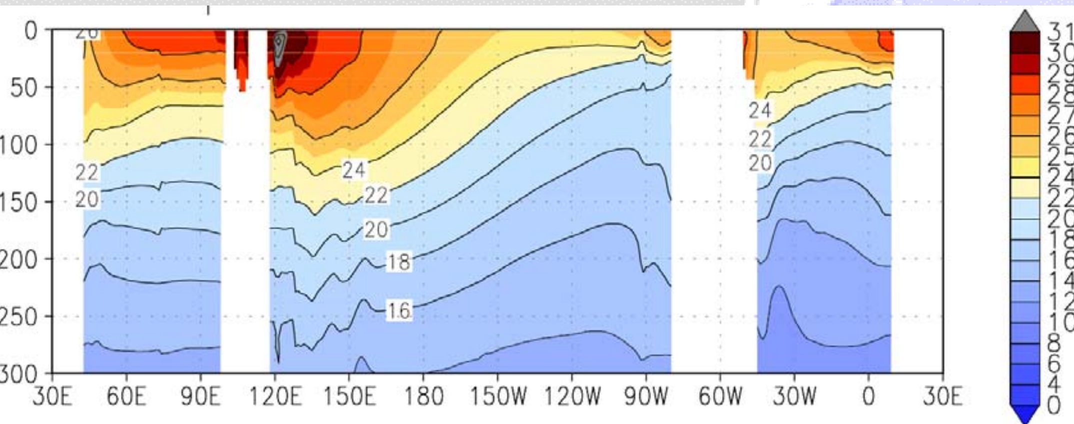
WOA01



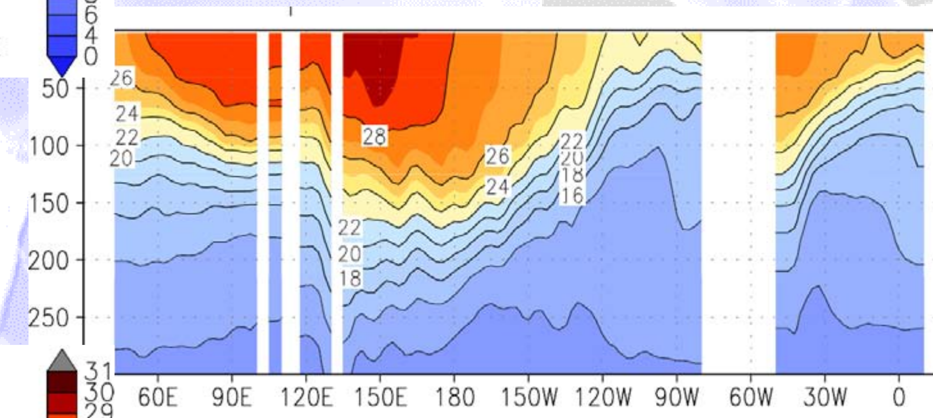
Overall performance of the model

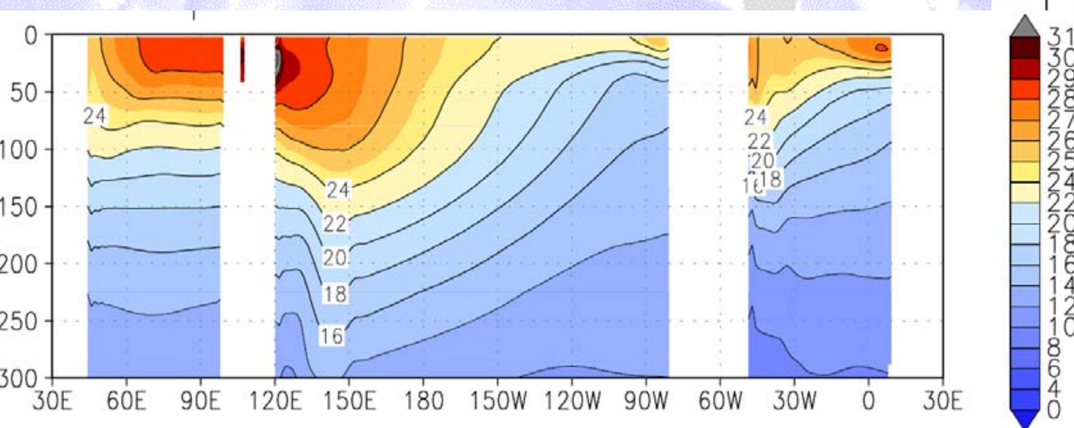
Equatorial thermocline



High-res.

Observed

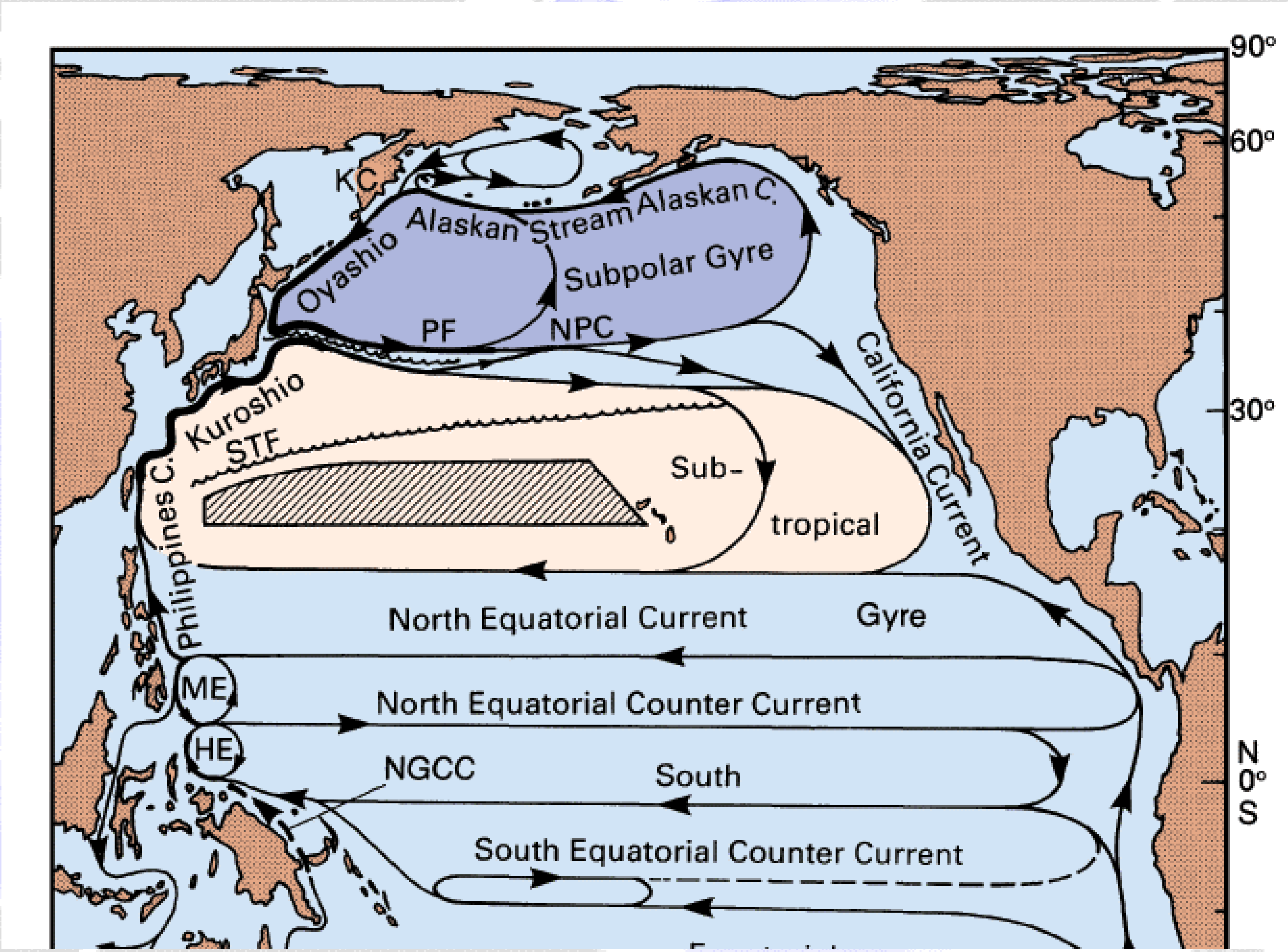




Medium-res.

Surface Currents for the Present Climate

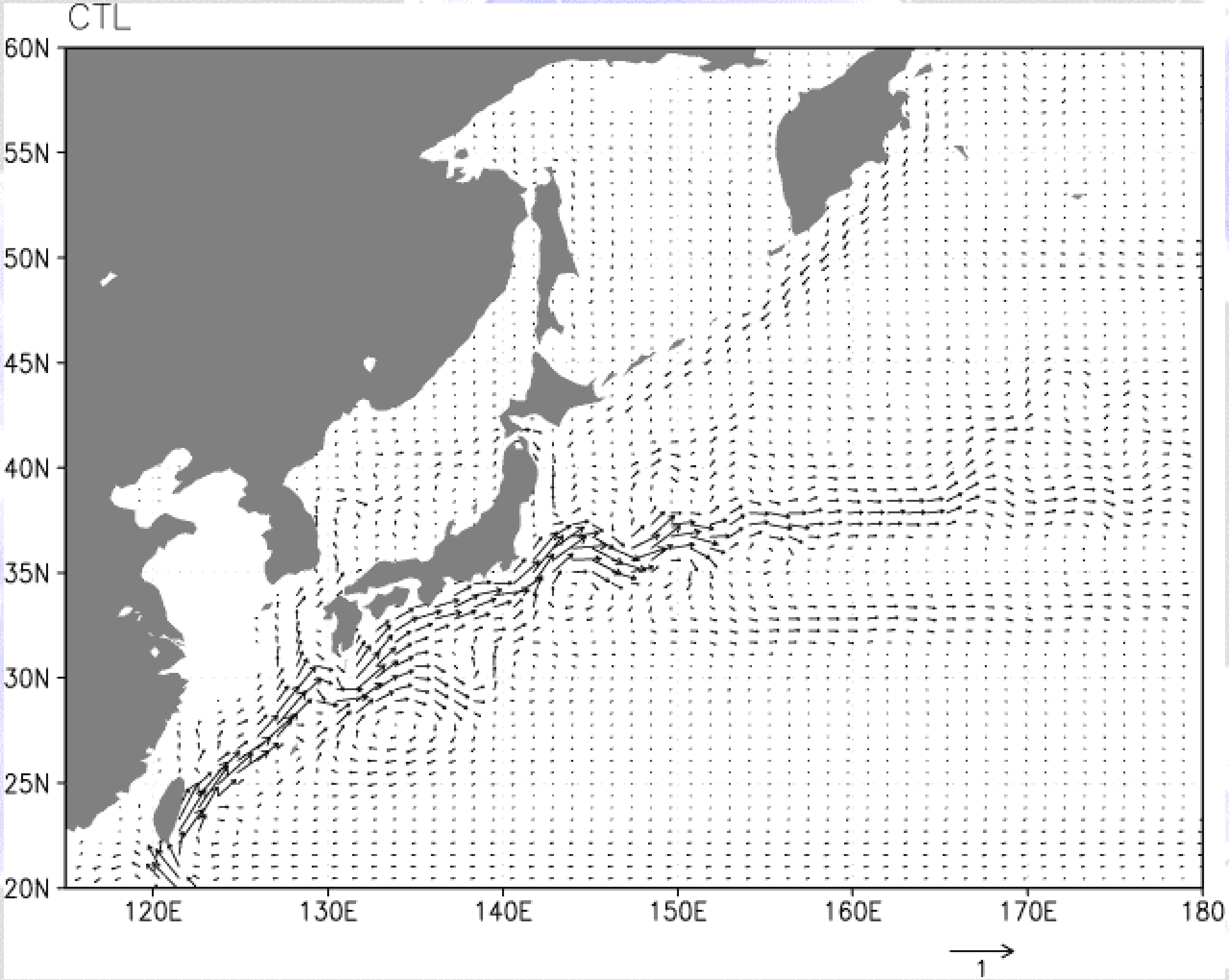
Surface currents in the North Pacific



Tomczak and Godfrey (2002)

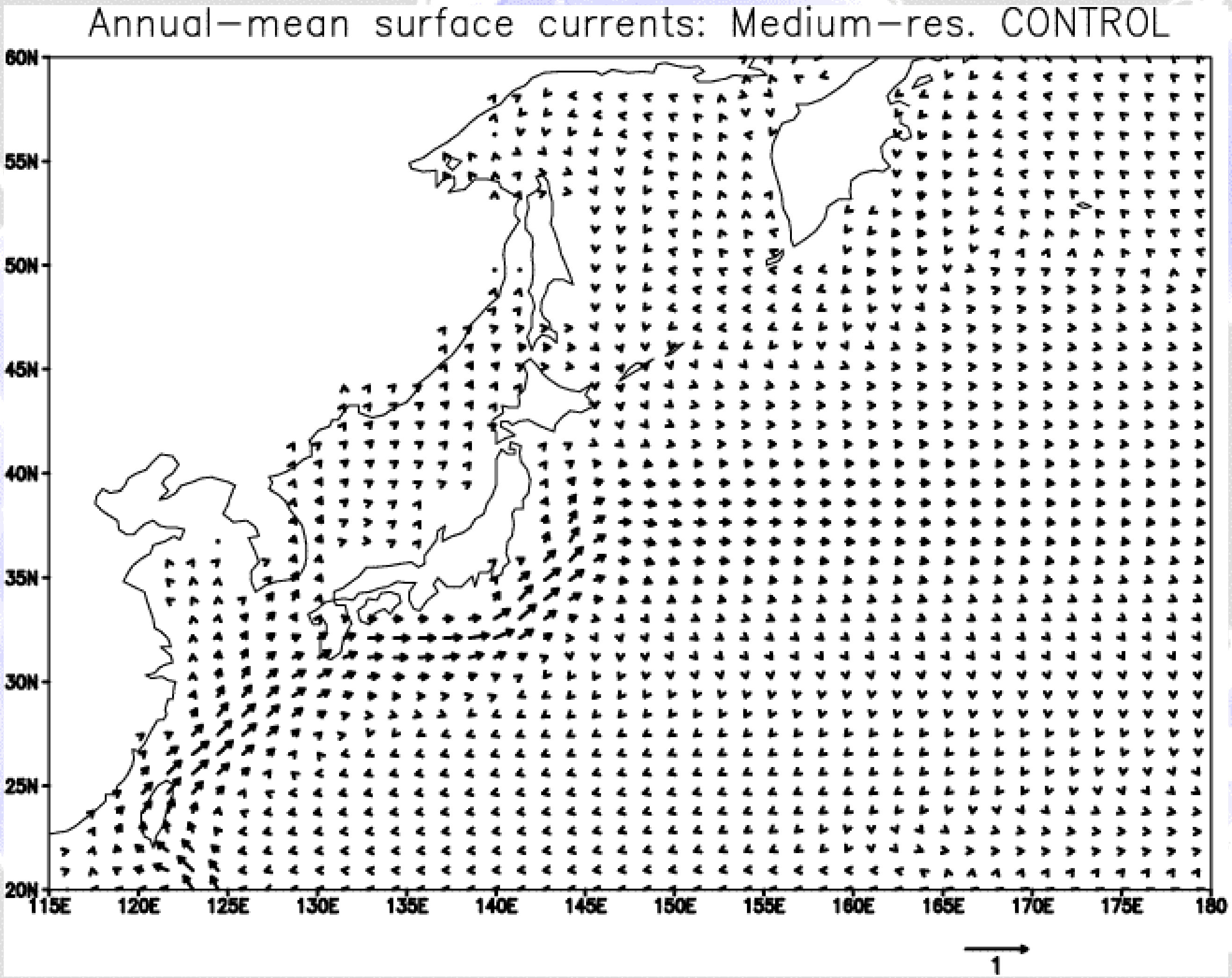
Surface Currents for the Present Climate

Kuroshio and Oyashio: High-res. 100m velocity



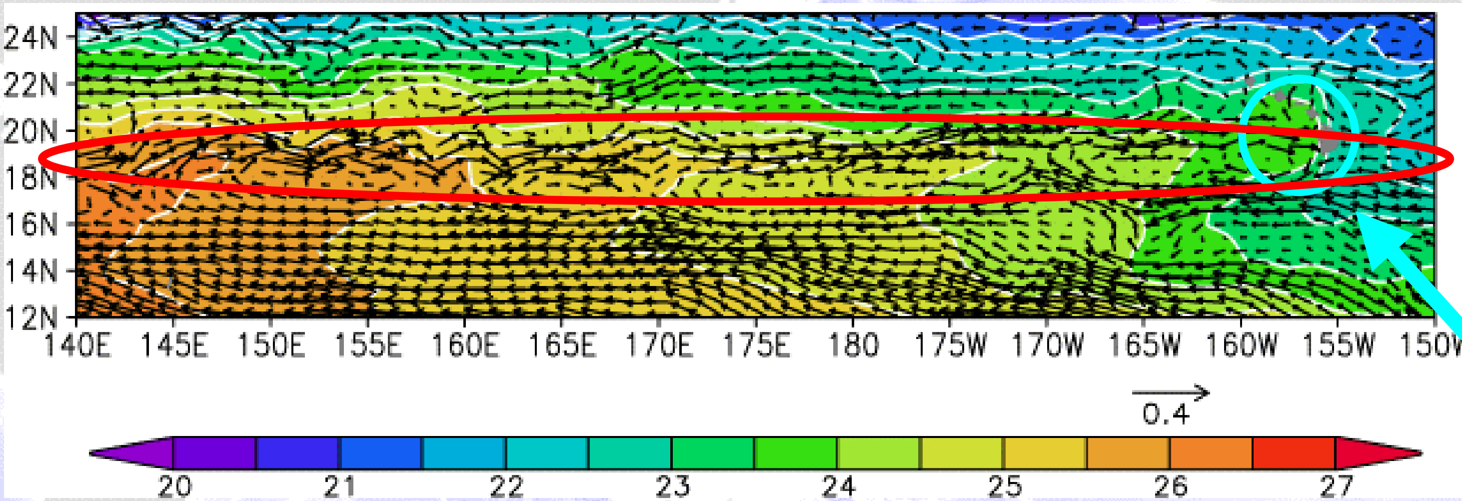
Surface Currents for the Present Climate

Kuroshio and Oyashio: Medium-res. 100m velocity



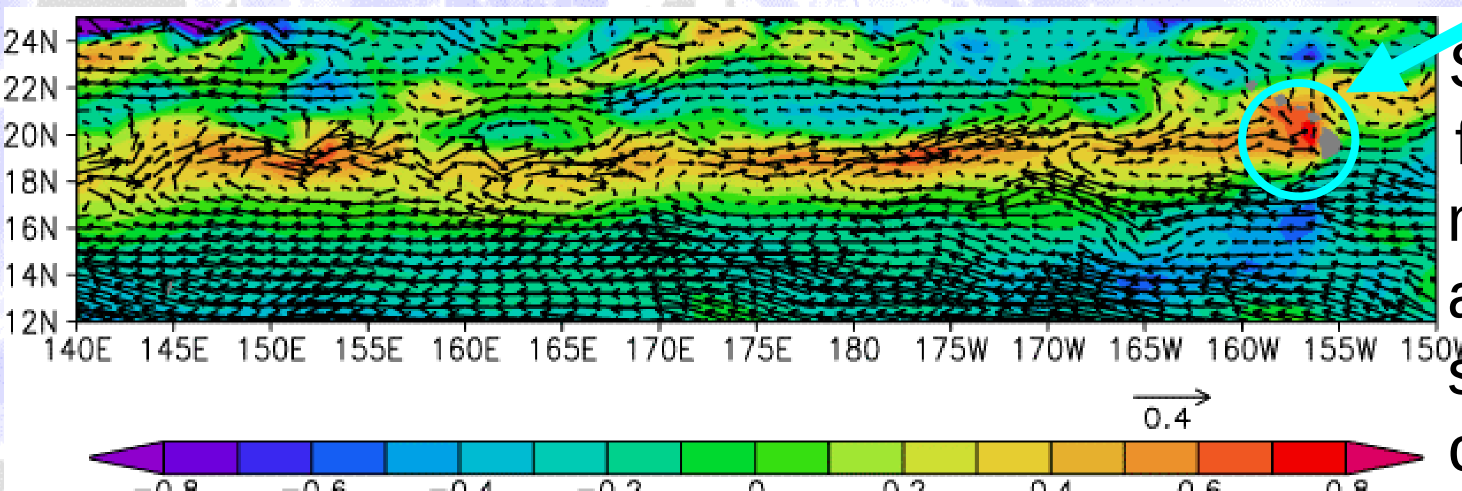
Surface Currents for the Present Climate

Hawaiian Lee Counter Current



SST and surface currents

Hawaii

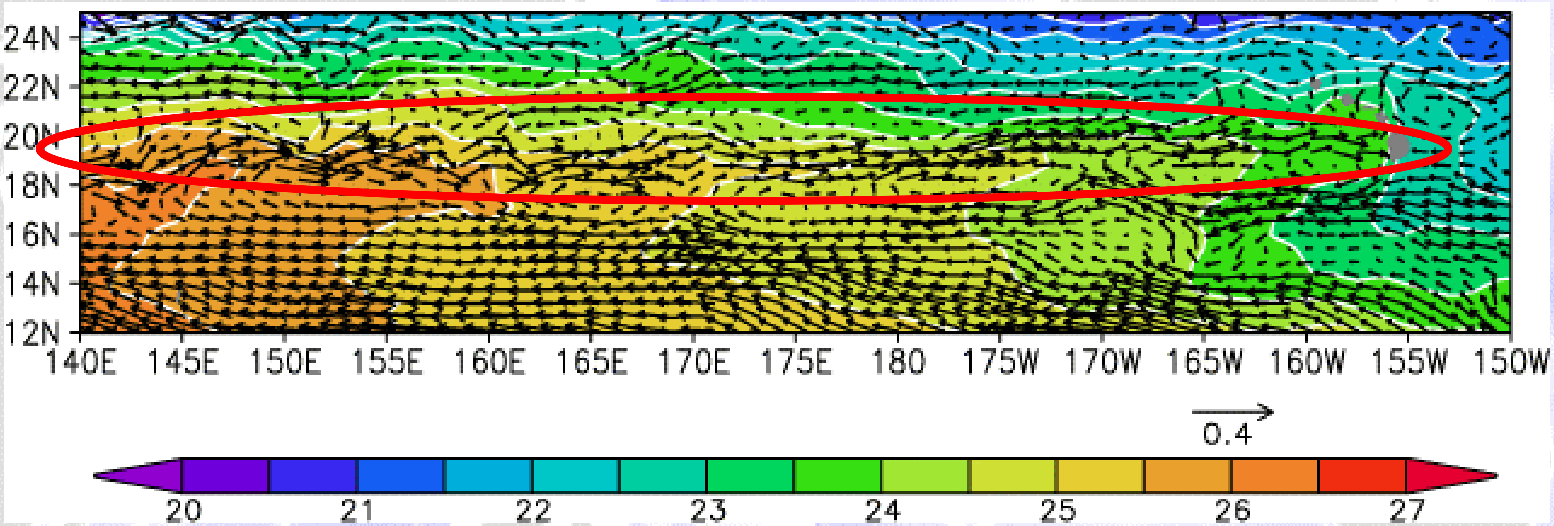


SST anomaly from 5°-width meridional average and surface currents

Sakamoto et al. (2004)

Surface Currents for the Present Climate

Hawaiian Lee Counter Current



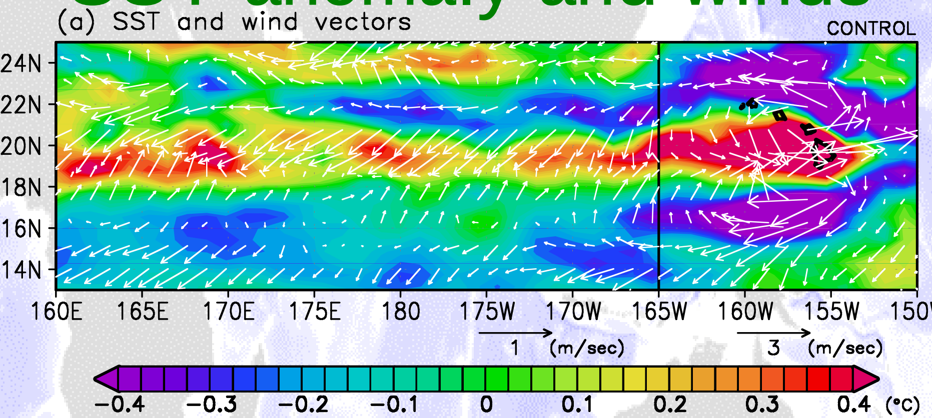
Local dipole wind-curl in the Hawaiian lee
→Thermocline shoaling to the north
→ Westward propagation of the thermocline slope by Rossby waves

Xie et al. (2001)

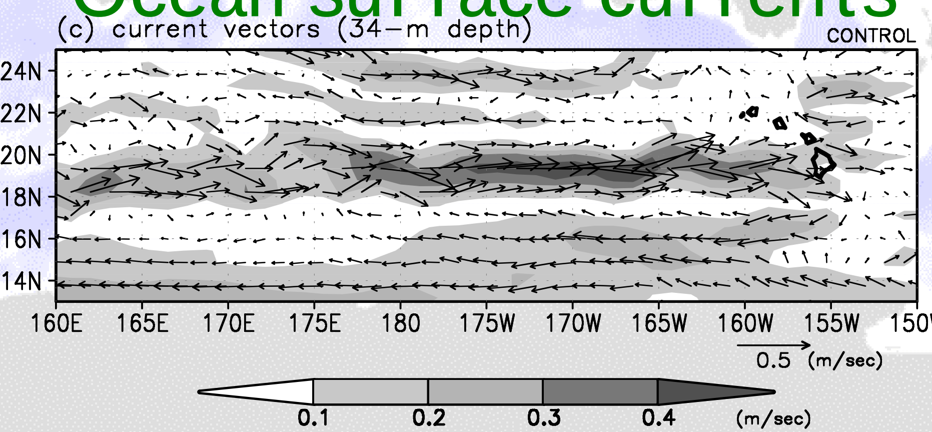
Surface Currents for the Present Climate

Hawaiian Lee Counter Current

SST anomaly and winds



Ocean surface currents



Local dipole wind-curl due to an orographic effect of the Hawaiian lee under the trades

→ Thermocline shoals to the north

→ Westward propagation of the thermocline slope by Rossby waves

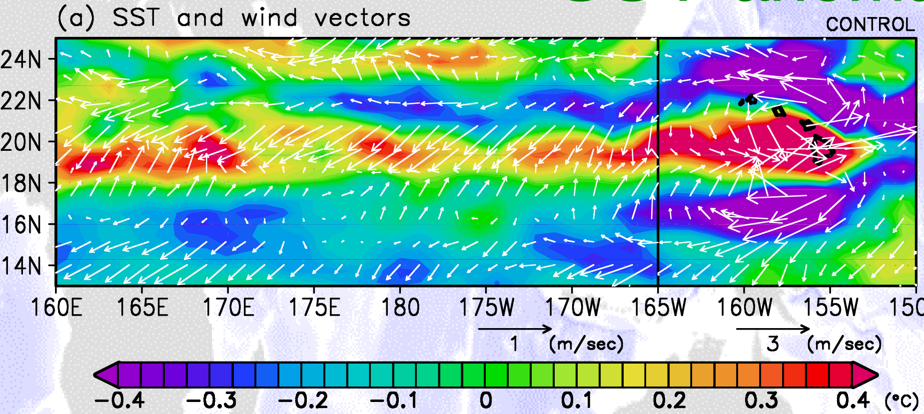
(Xie et al., 2001)

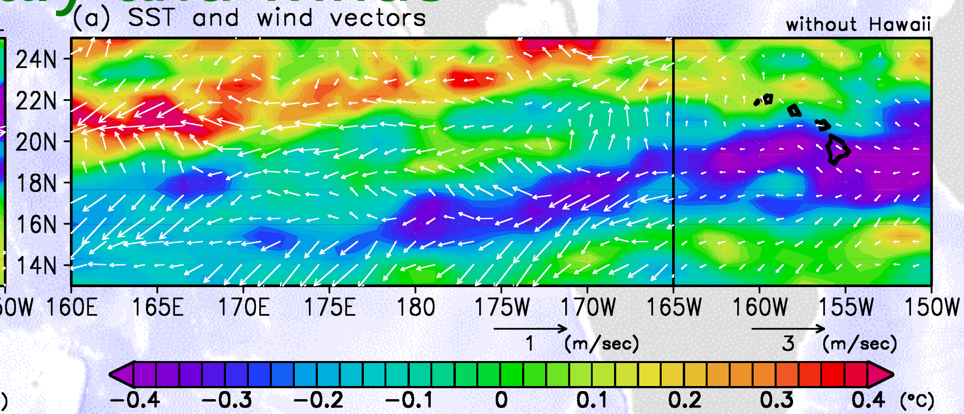
Surface Currents for the Present Climate

Hawaiian Lee Counter Current

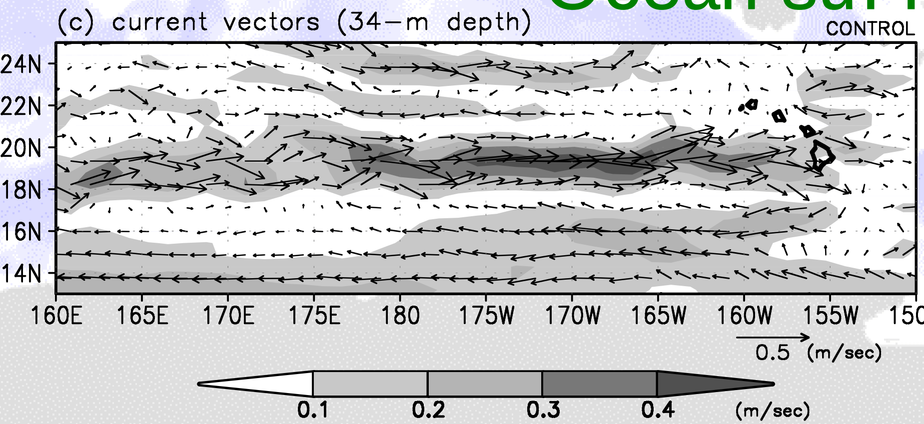
with Hawaii | without Hawaii

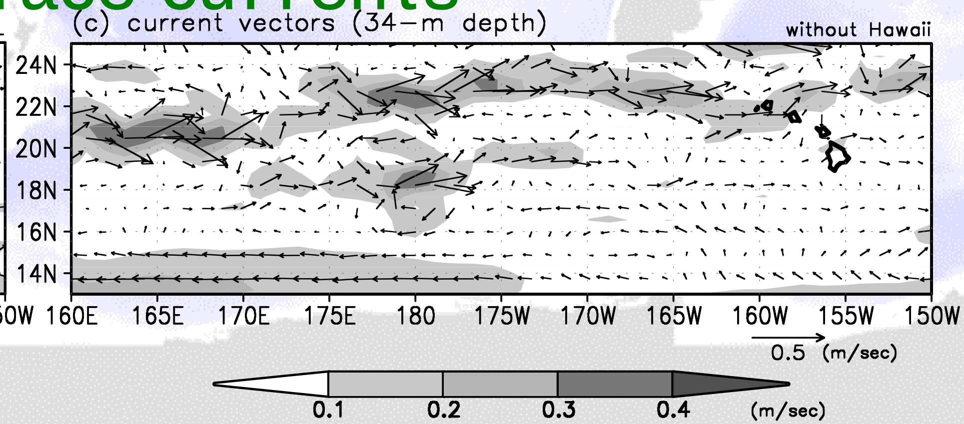
SST anomaly and winds





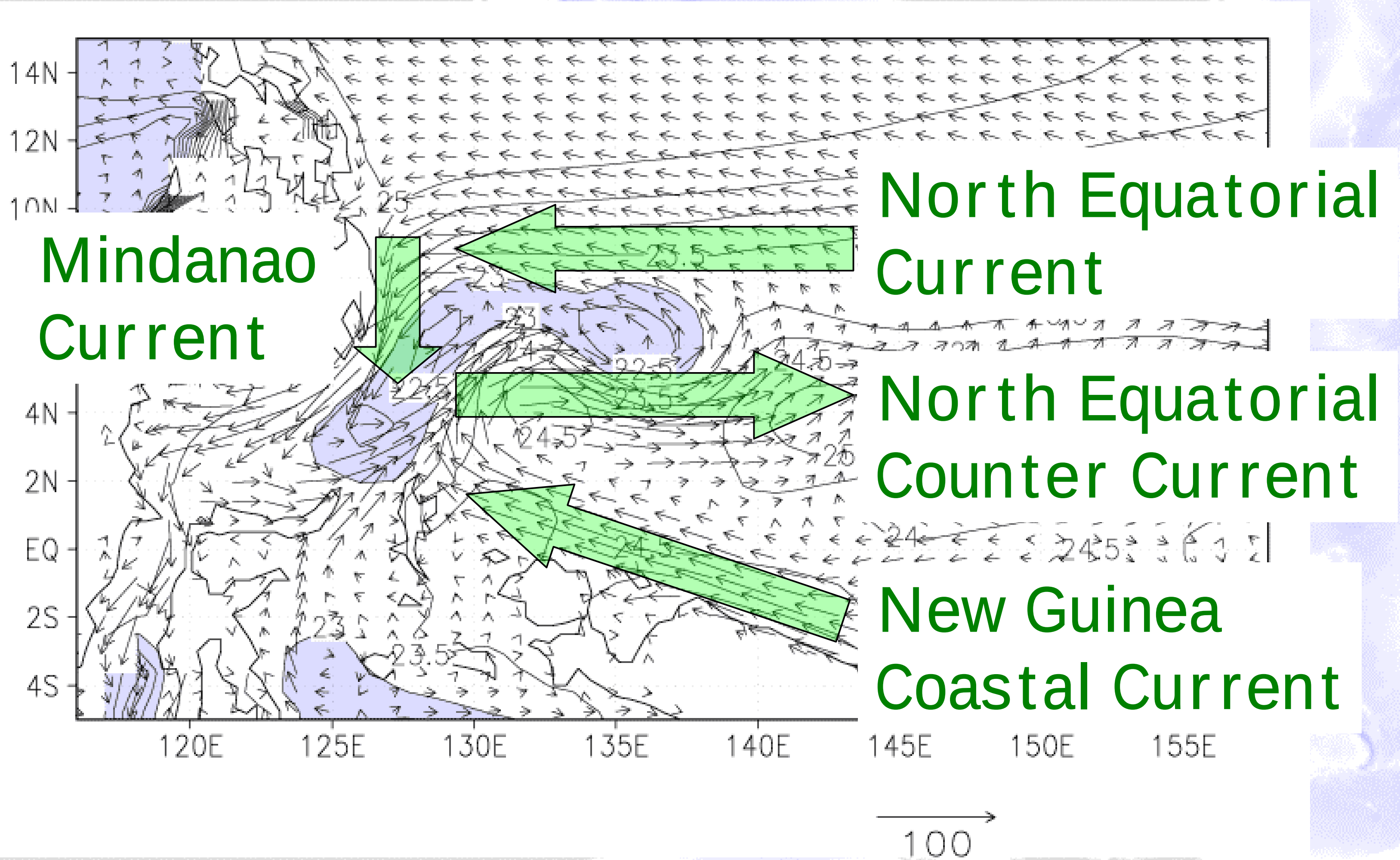
Ocean surface currents





Surface Currents for the Present Climate

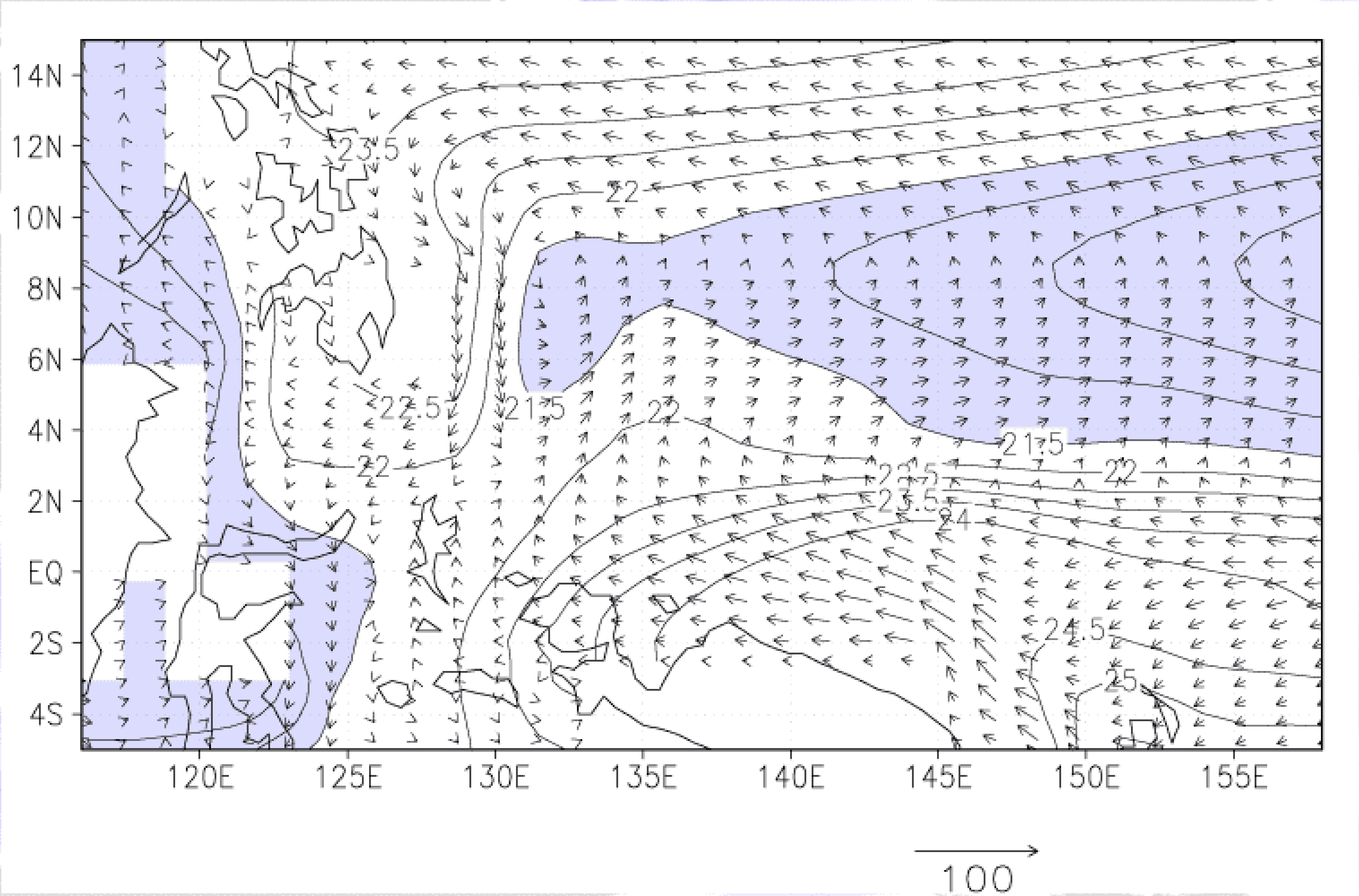
Equatorial currents and Mindanao Dome



Suzuki et al. (2005)

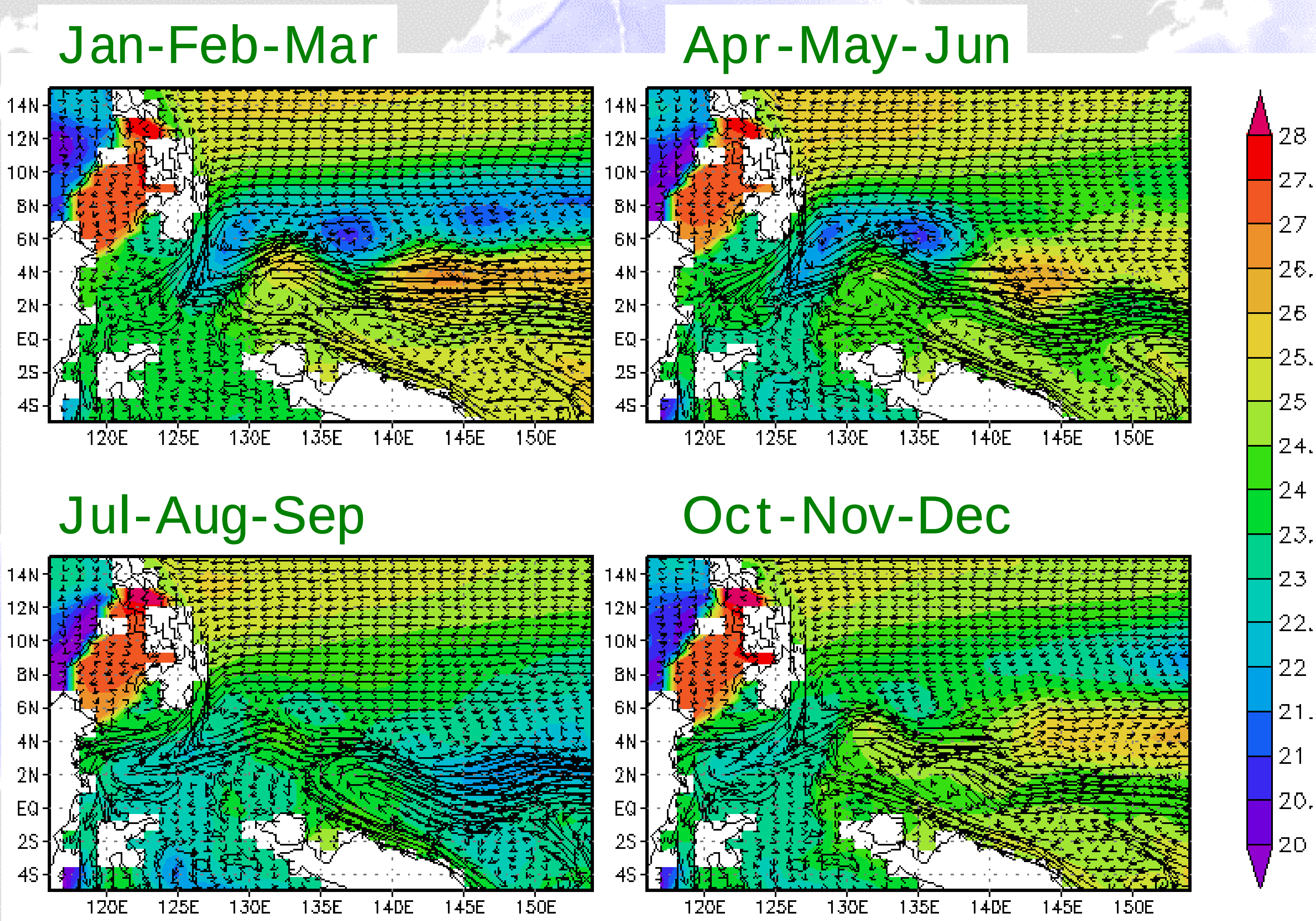
Surface Currents for the Present Climate

Equatorial currents and Mindanao Dome



Surface Currents for the Present Climate

Seasonal cycle of the Mindanao Dome

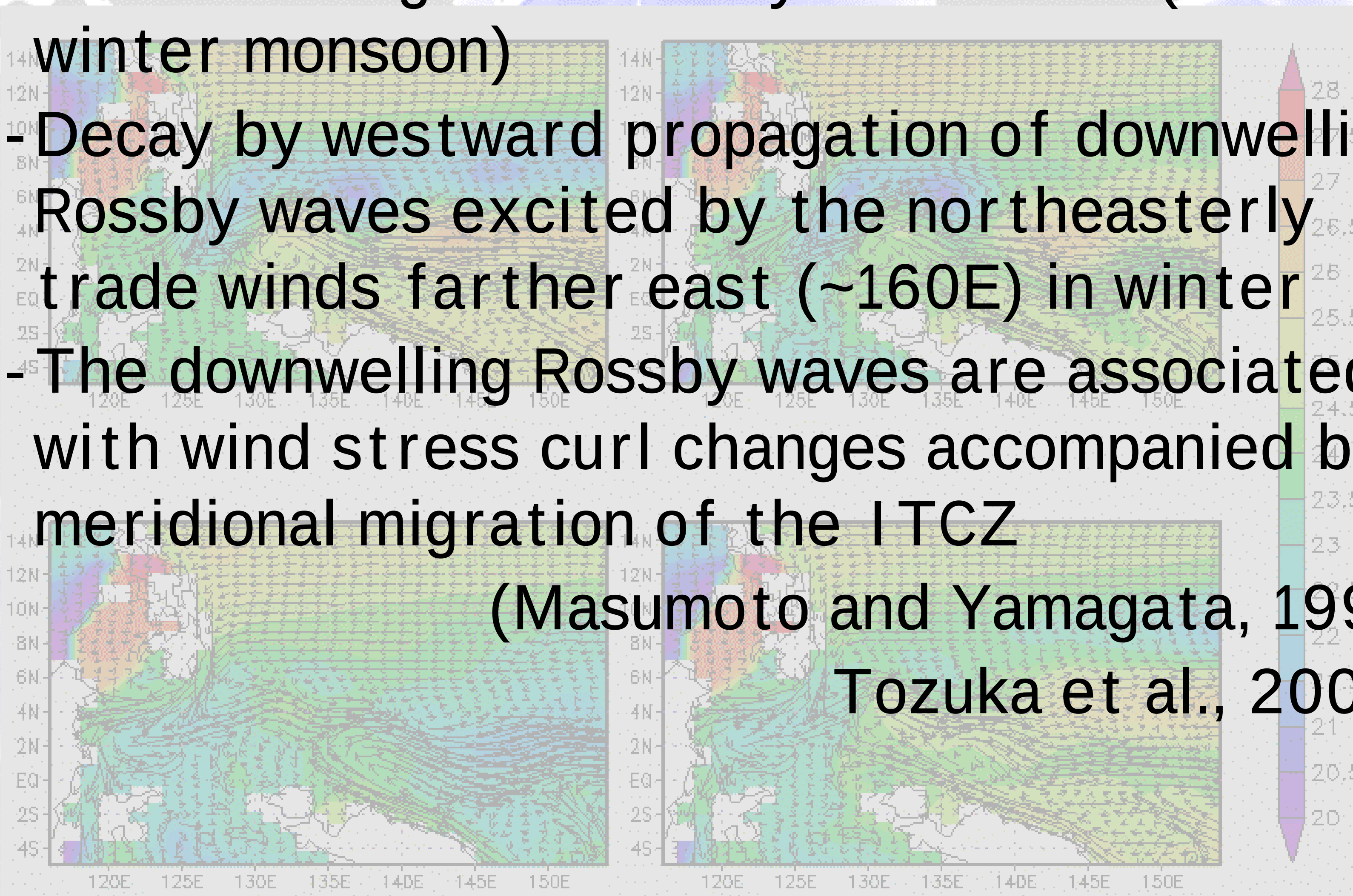


Surface Currents for the Present Climate

Seasonal cycle of the Mindanao Dome

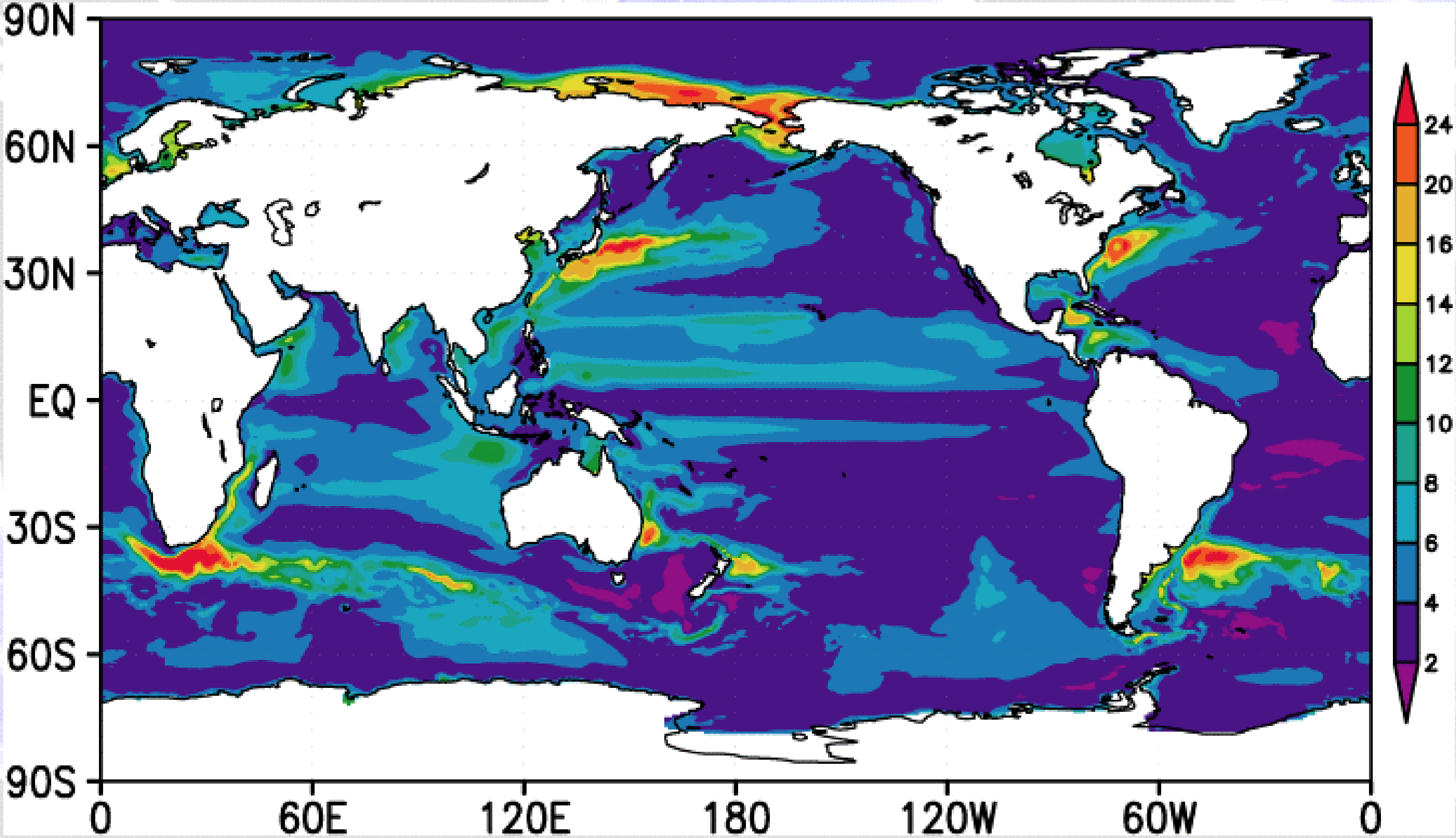
- Wintertime generation by local winds (Asian winter monsoon)
- Decay by westward propagation of downwelling Rossby waves excited by the northeasterly trade winds farther east (~160E) in winter
- The downwelling Rossby waves are associated with wind stress curl changes accompanied by meridional migration of the ITCZ

(Masumoto and Yamagata, 1991; Tozuka et al., 2002)



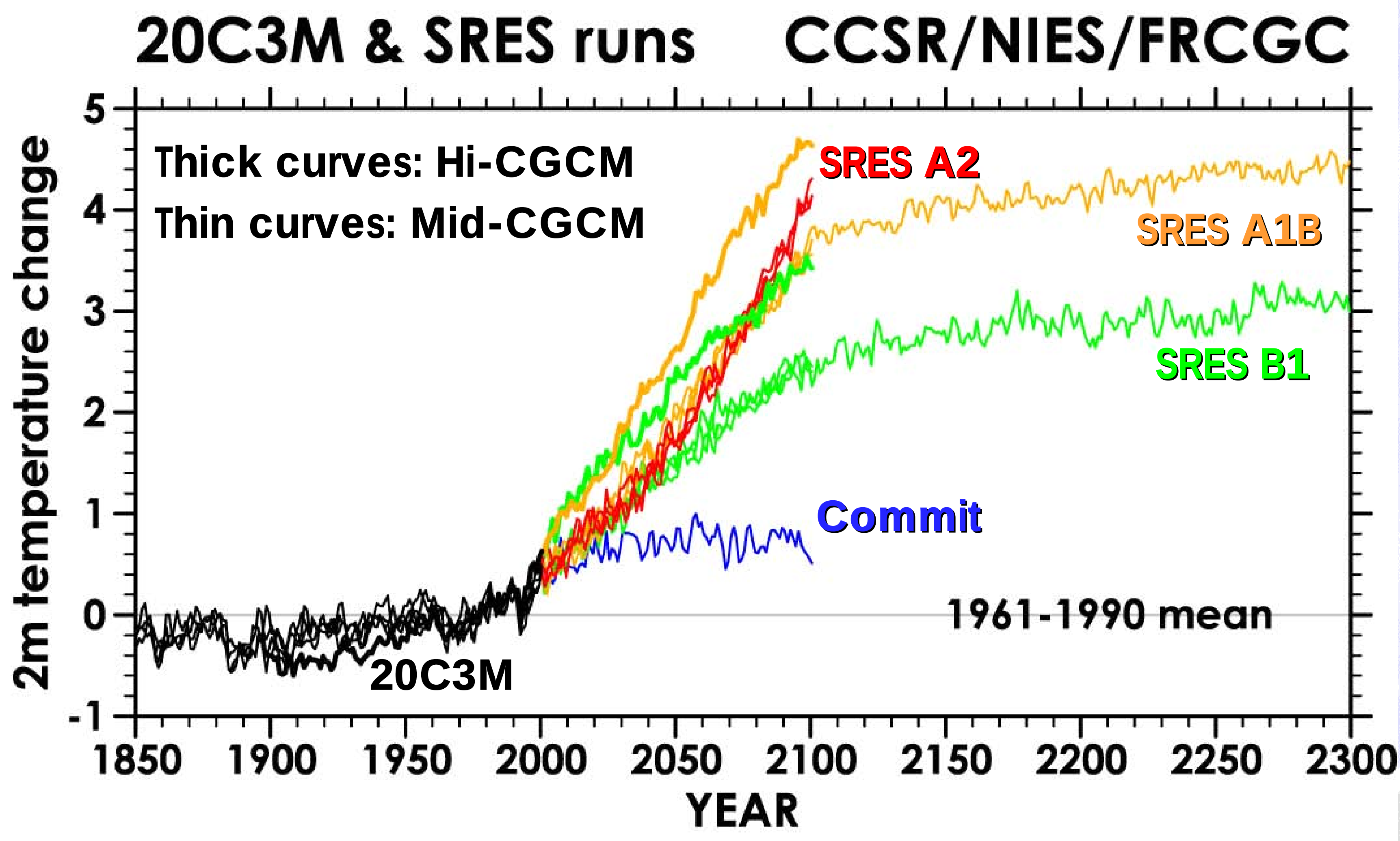
Surface Currents for the Present Climate

Sea surface height variability (standard dev.)



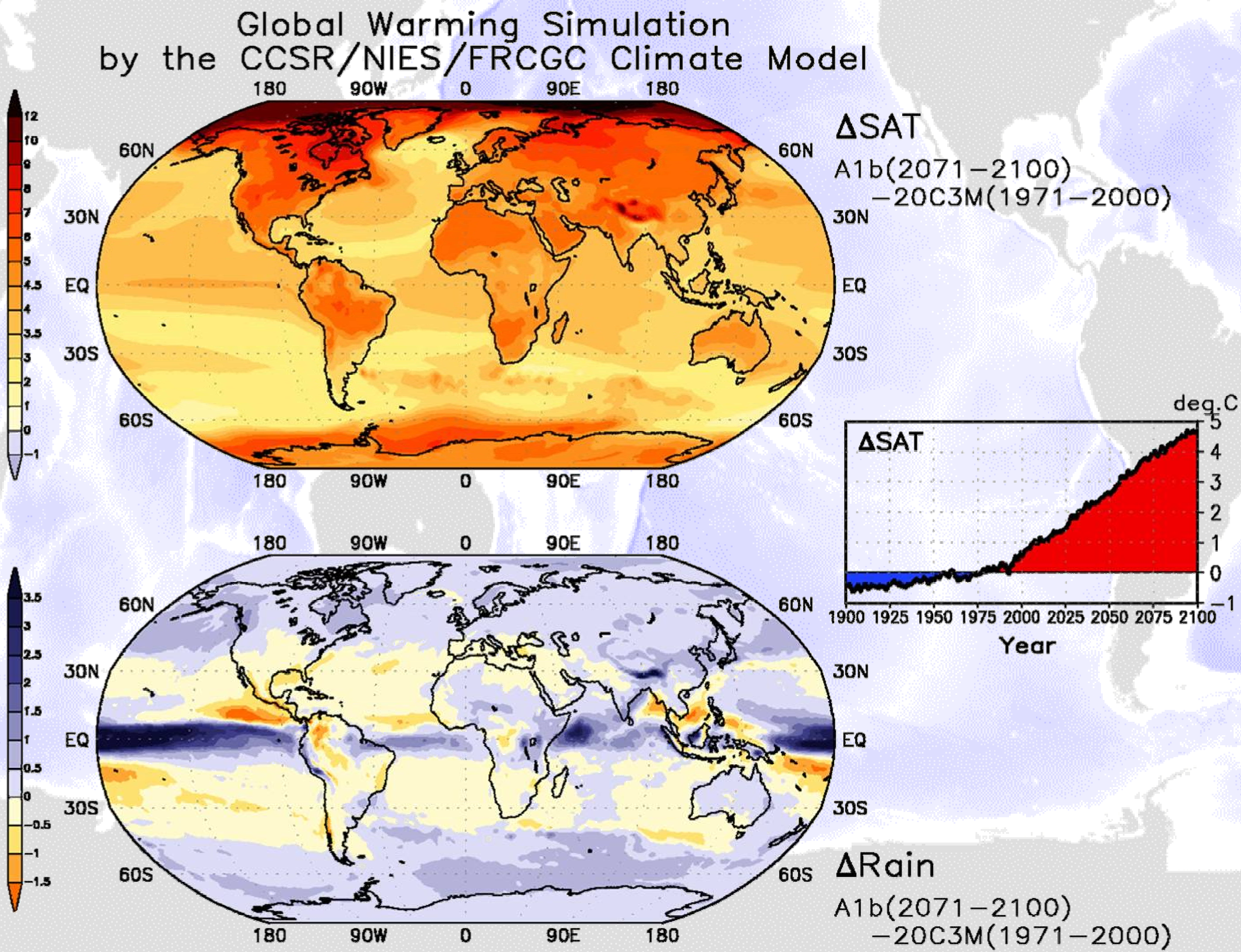
Global Warming Climate

Global-mean surface air temperature change



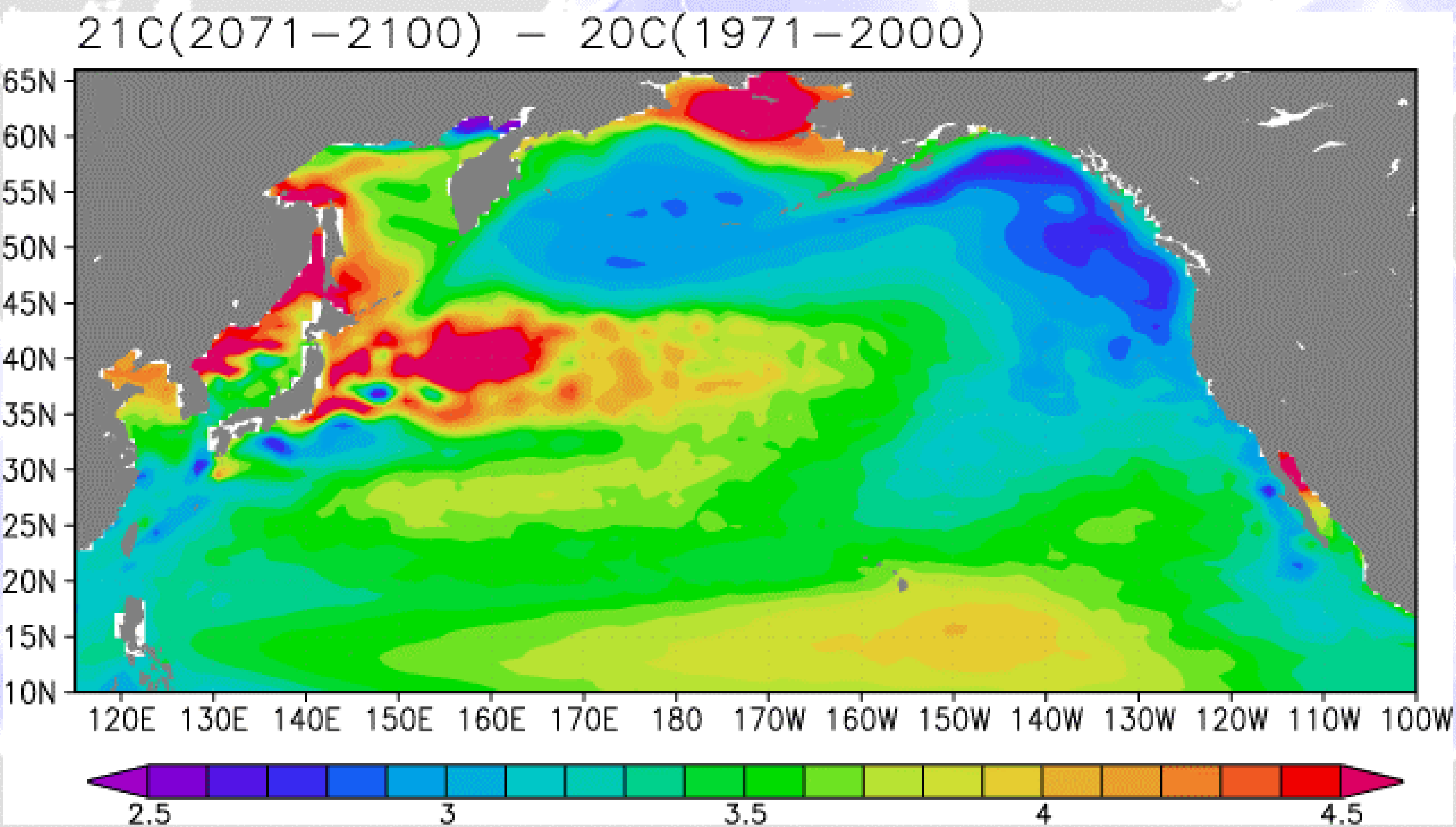
Global Warming Climate

Surface air temperature change for A1B scenario



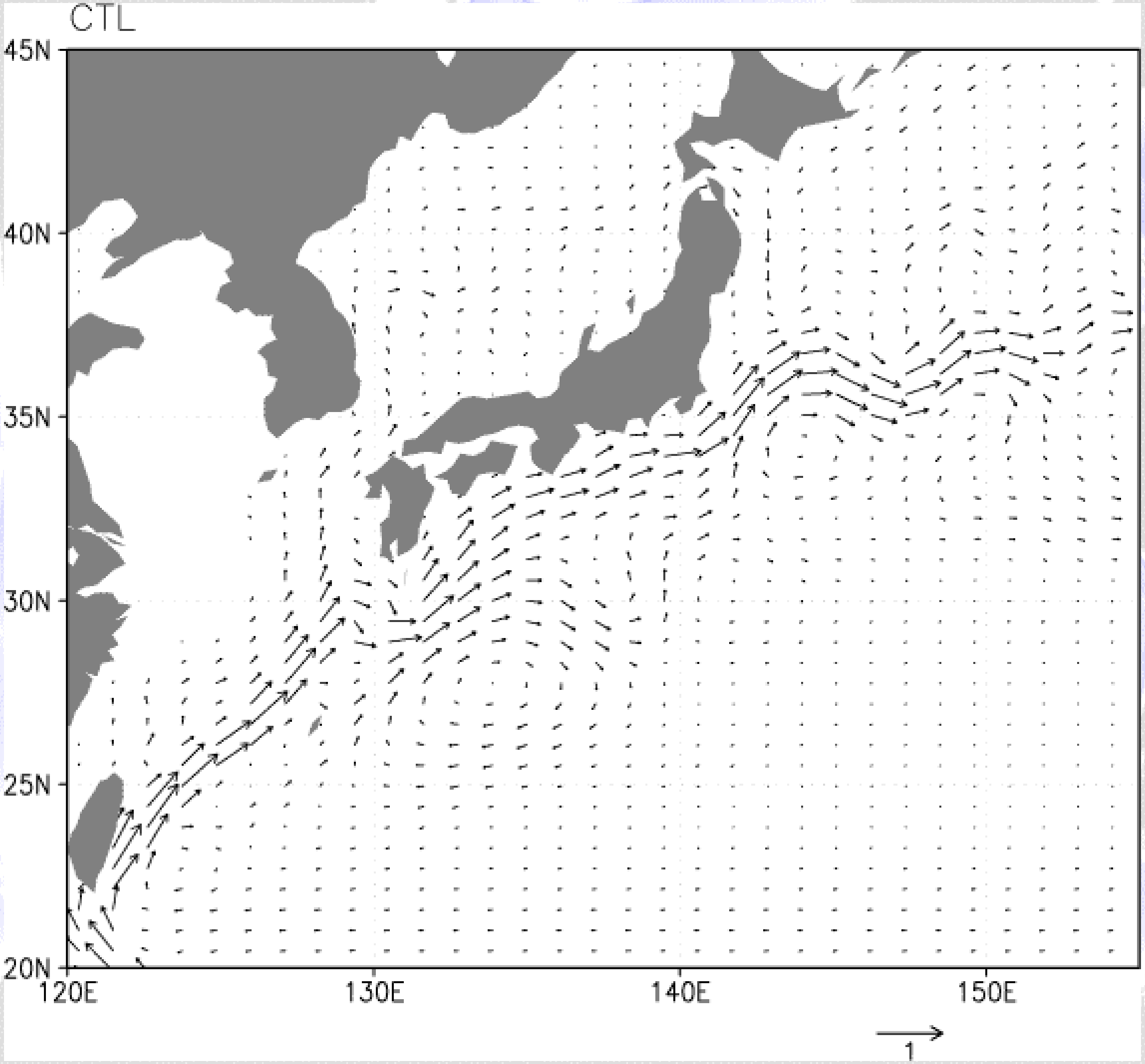
Global Warming Climate

Pacific SST change for A1B scenario



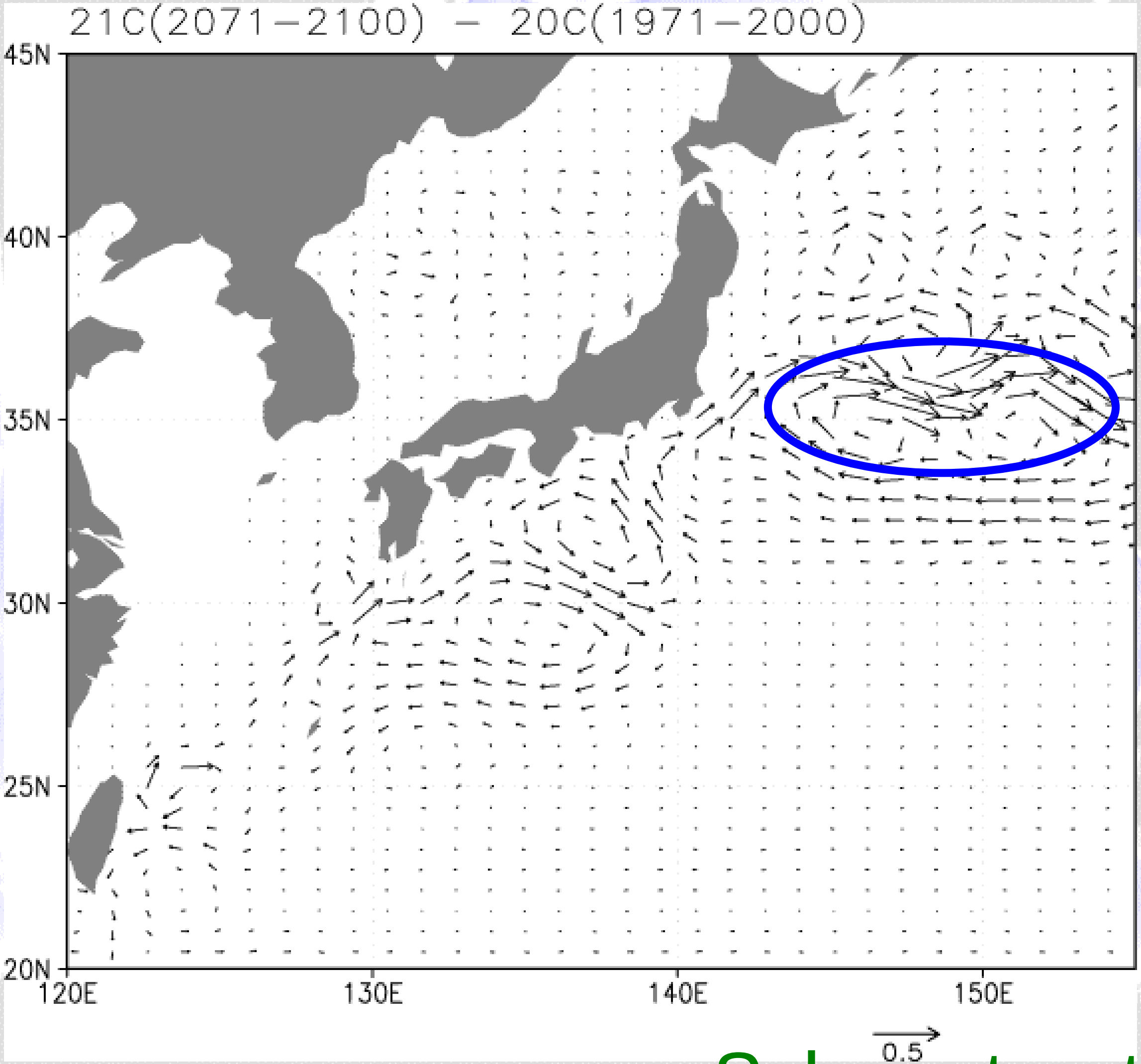
Global Warming Climate

Kuroshio: 100 yr average of the control case



Global Warming Climate

Kuroshio: (2071-2100 of A1B) – (1971-2000)

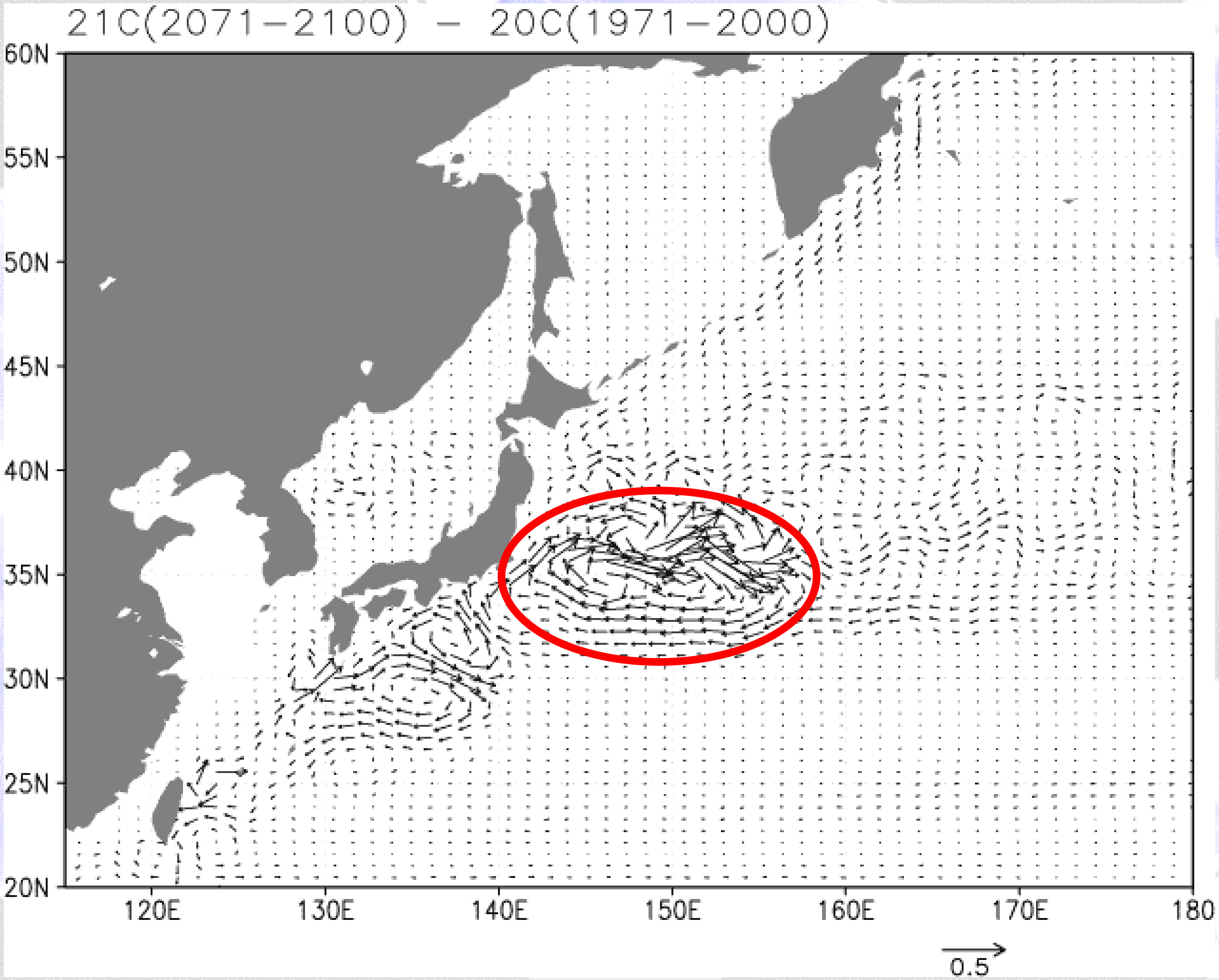


+30 cm/s

Sakamoto et al. (2005)

Global Warming Climate

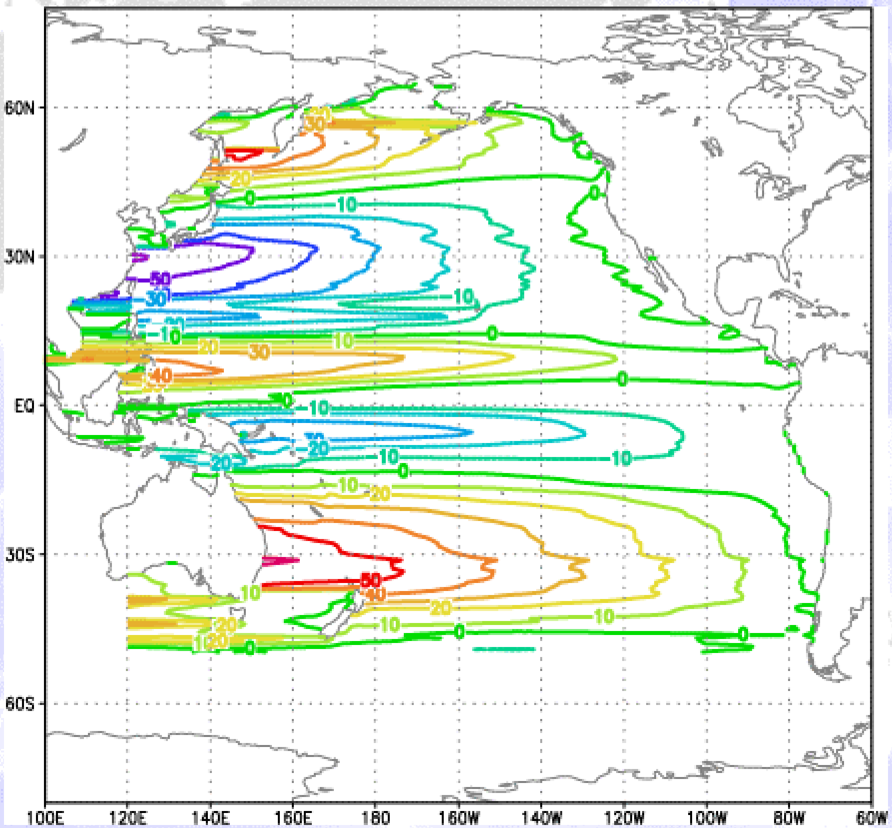
Surface currents: (2071-2100 of A1B) – (1971-2000)



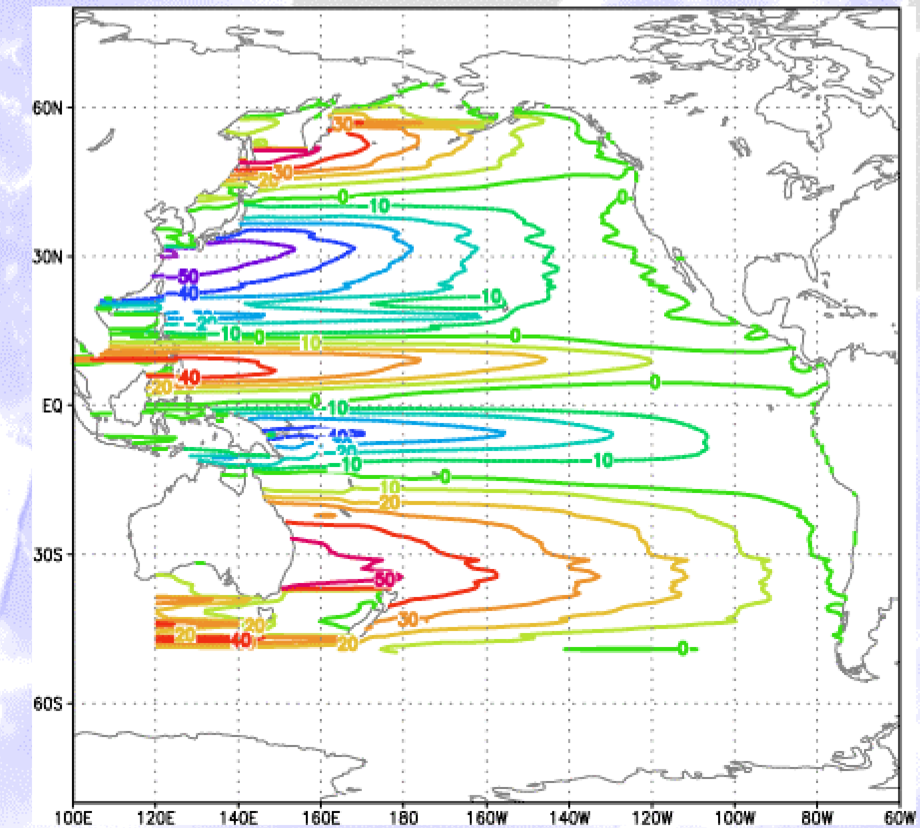
Sakamoto et al. (2005)

Global Warming Climate

Sverdrup transport



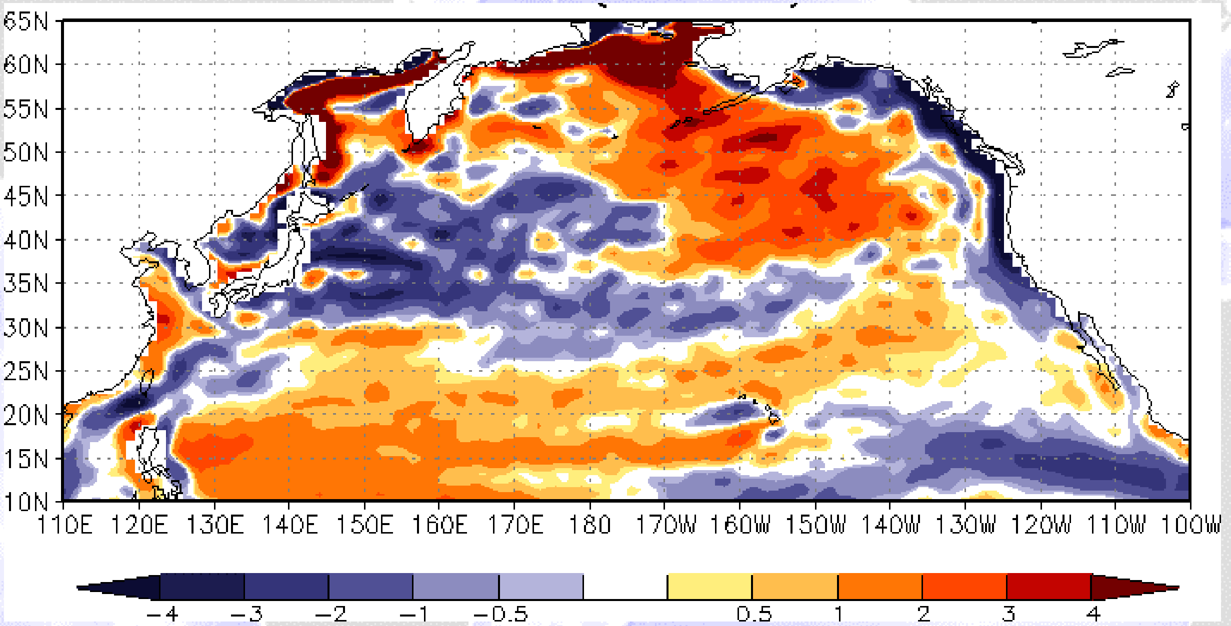
1971-2000



2071-2100

Global Warming Climate

Curl τ change: (2071-2100 of A1B) – (1971-2000)

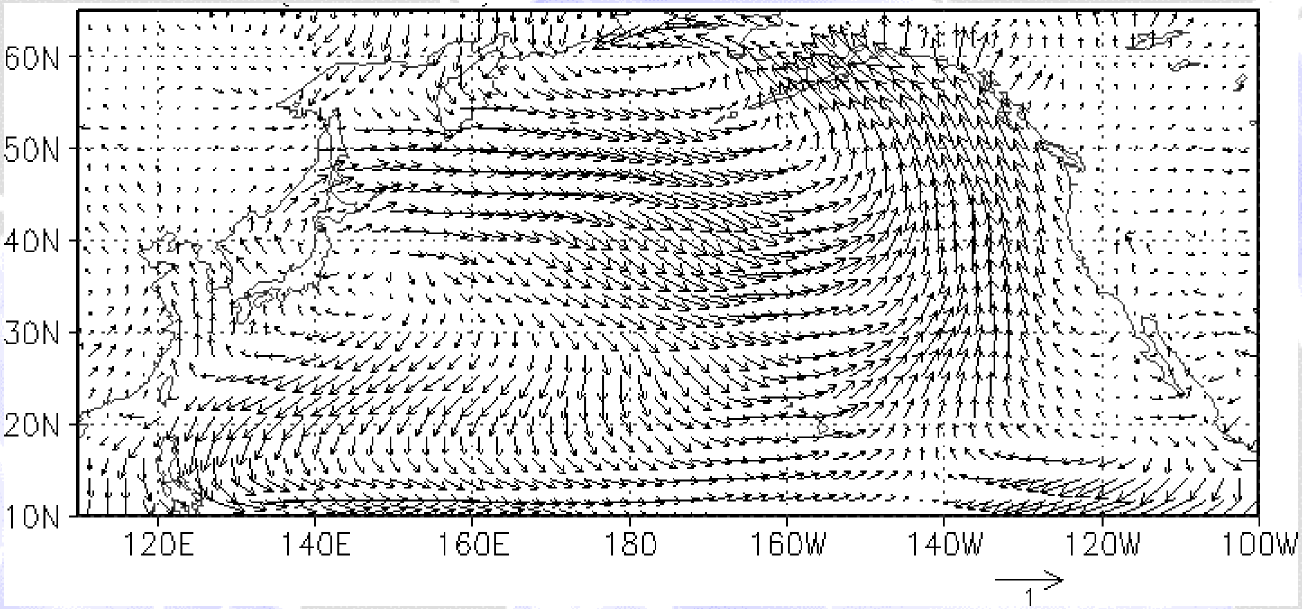


- Acceleration of the Kuroshio accounted for by Sverdrup transport ~5 Sv
- Actual acceleration ~30 Sv

Sakamoto et al. (2005)

Global Warming Climate

Wind change: (2071-2100 of A1B) – (1971-2000)



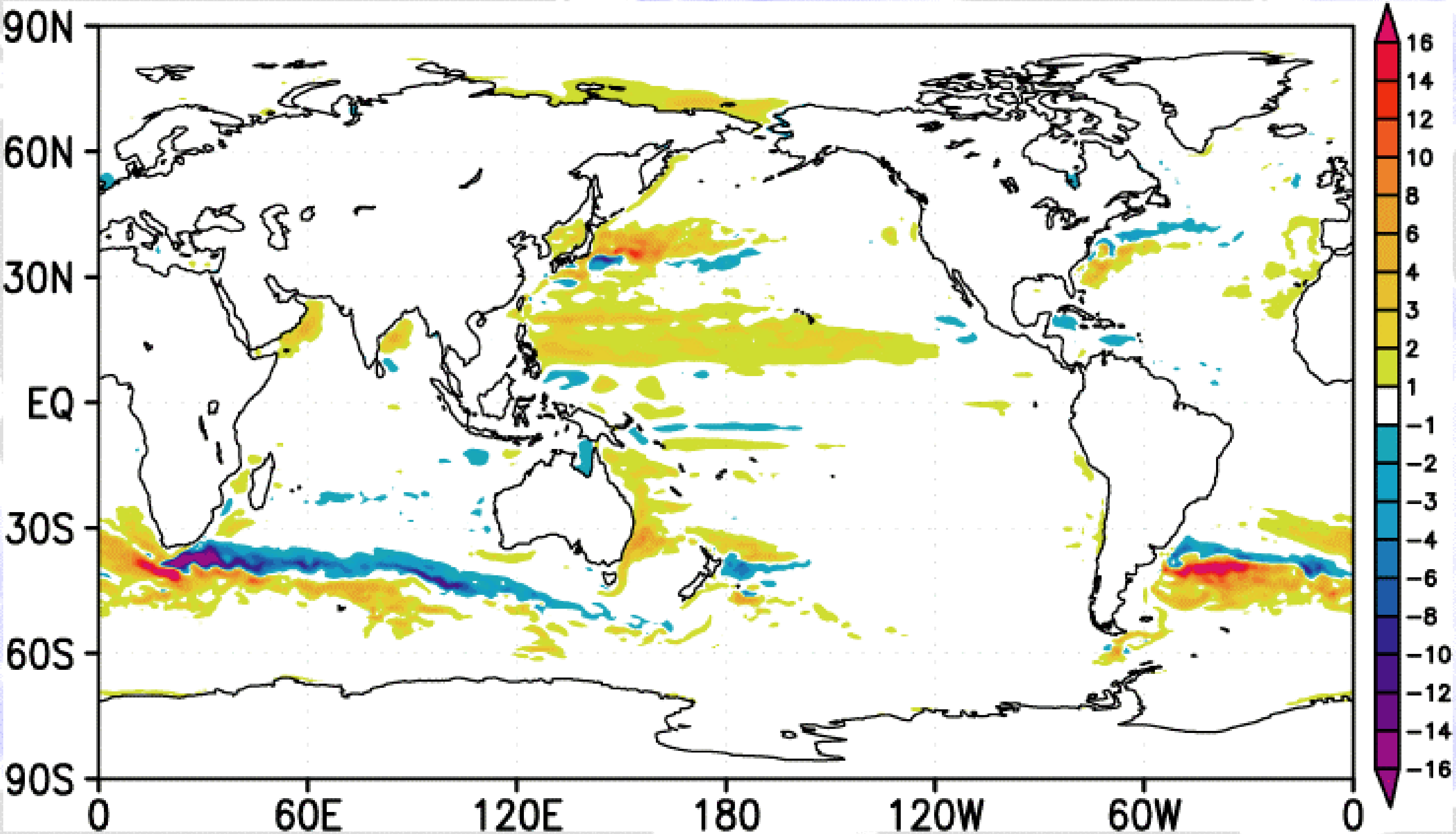
- Weakened trades
- Intensified Aleutian Low

… El Nino-like response

Sakamoto et al. (2005)

Global Warming Climate

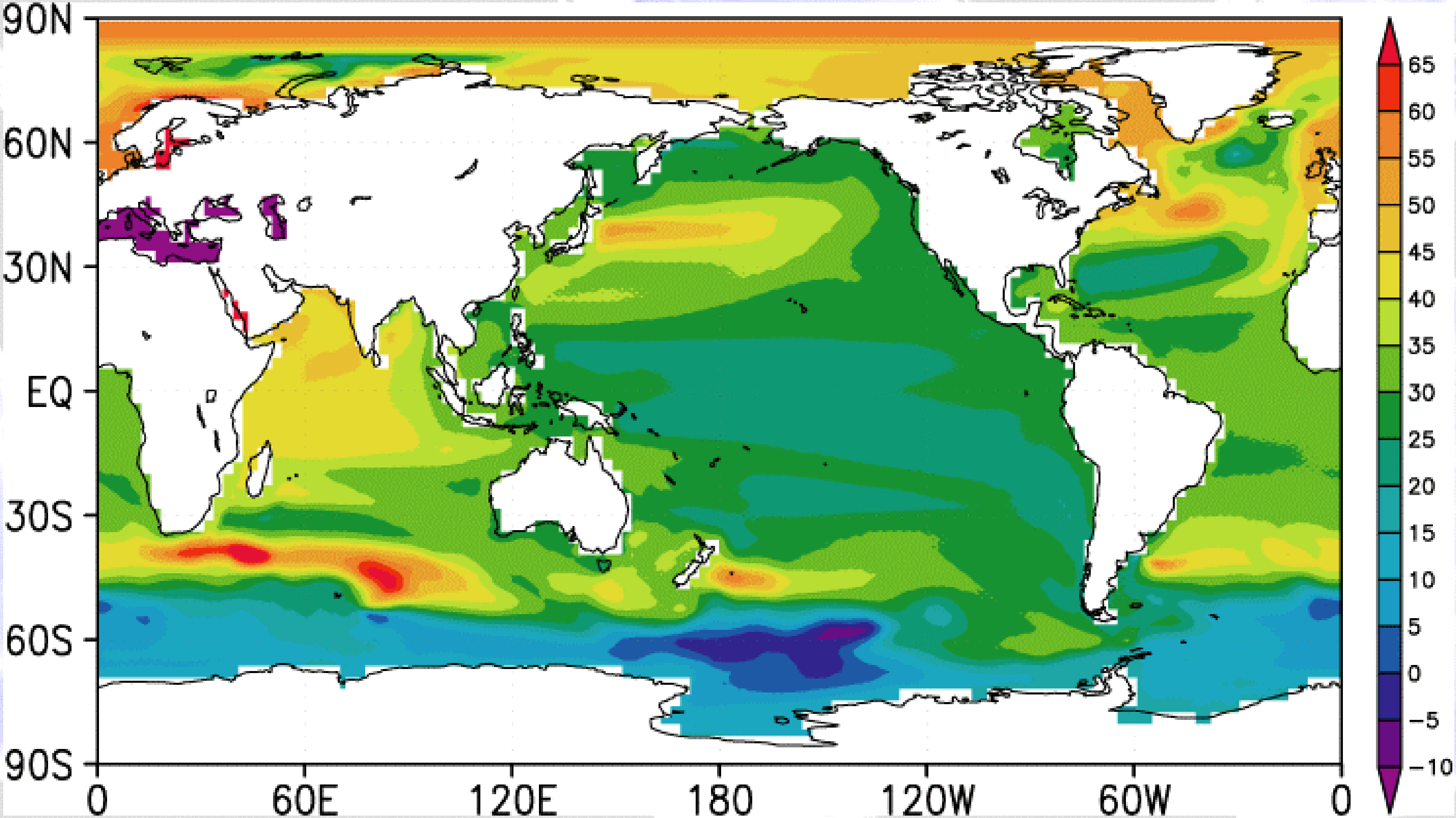
Change of sea surface height variability



Suzuki et al. (2005)

Global Warming Climate

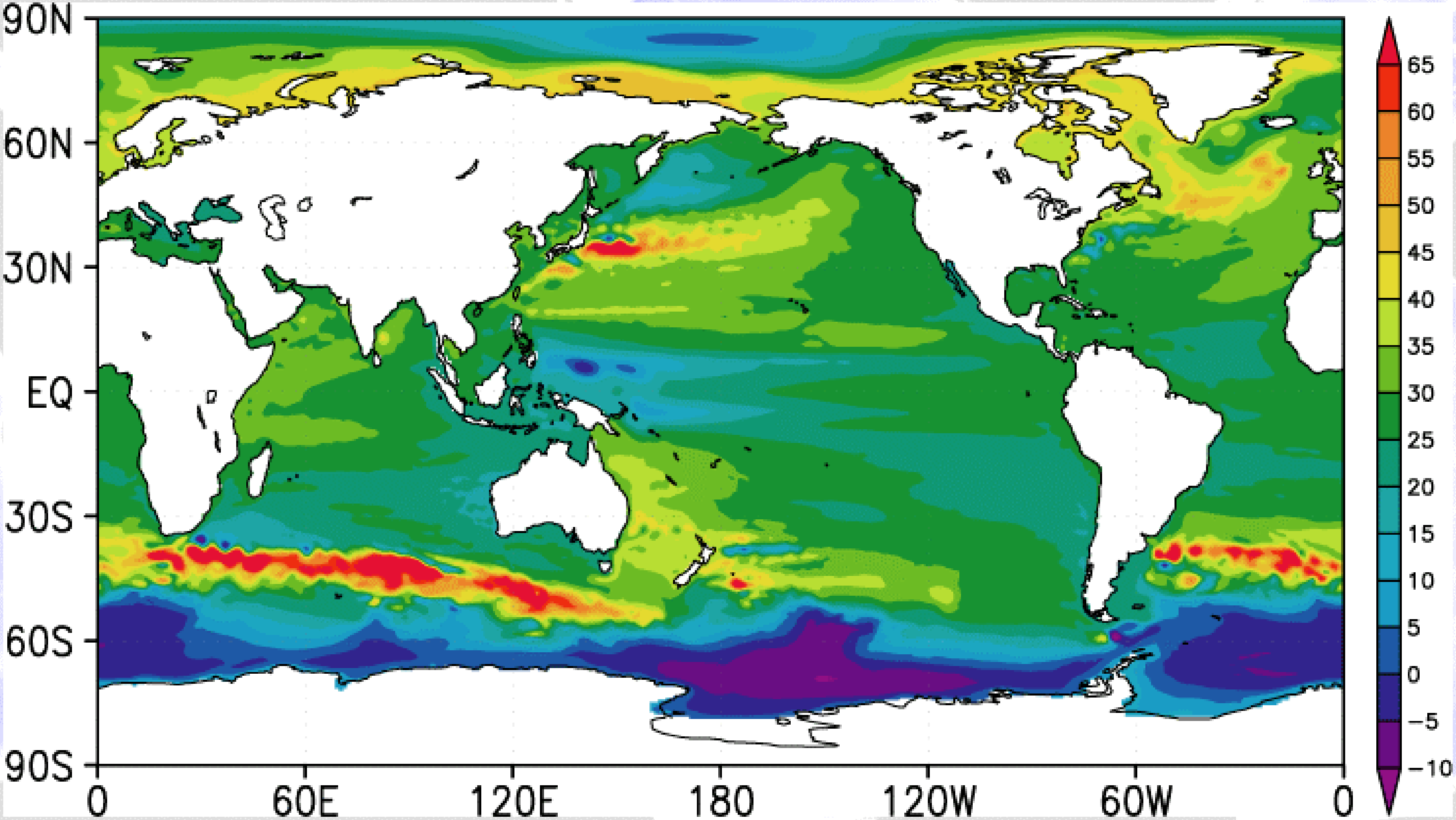
Sea level rise: Medium-res.



Suzuki et al. (2005)

Global Warming Climate

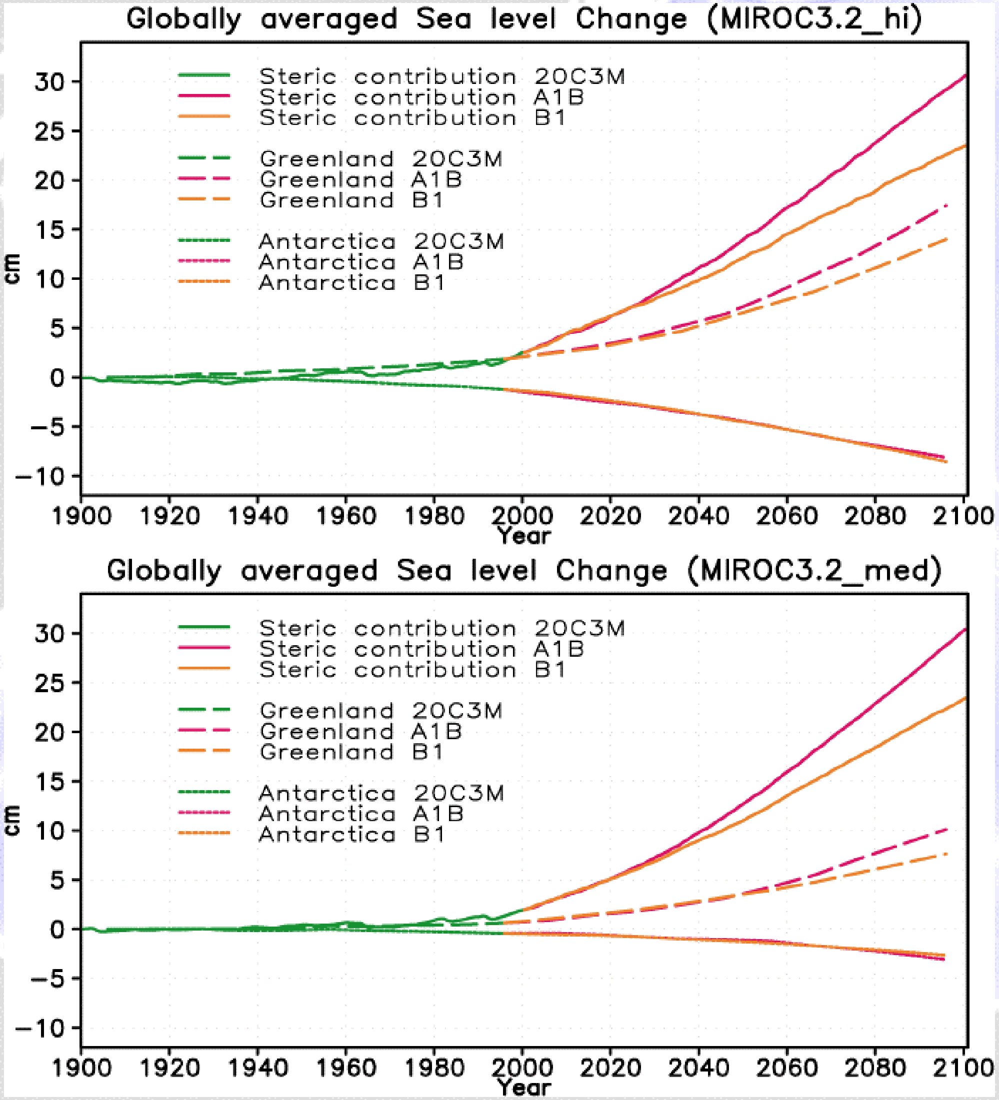
Sea level rise: High-res.



Suzuki et al. (2005)

Global Warming Climate

Global mean sea level rise



Suzuki et al. (2005)

Summary

- Western boundary currents and other swift surface currents have a large impact on the climate, so their proper representation in climate models is very important for studies of climate and its changes, especially of basin and regional scales
- Our high resolution model results are encouraging in this regard, though there still are many things to be done