Impact of parameterized interleaving process on the Pacific equatorial undercurrent and ENSO in a CGCM

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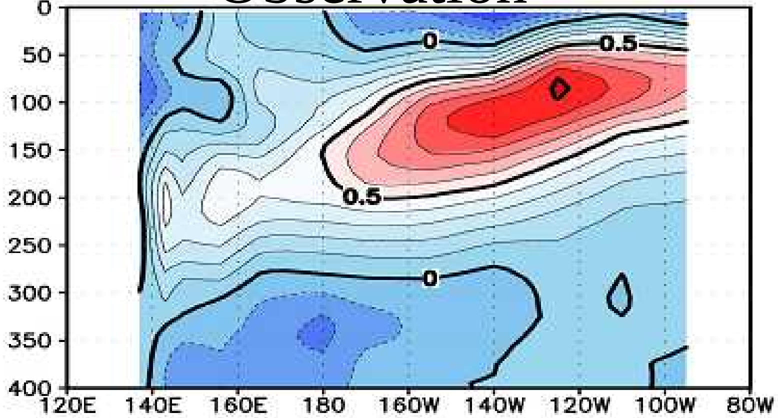
Introduction

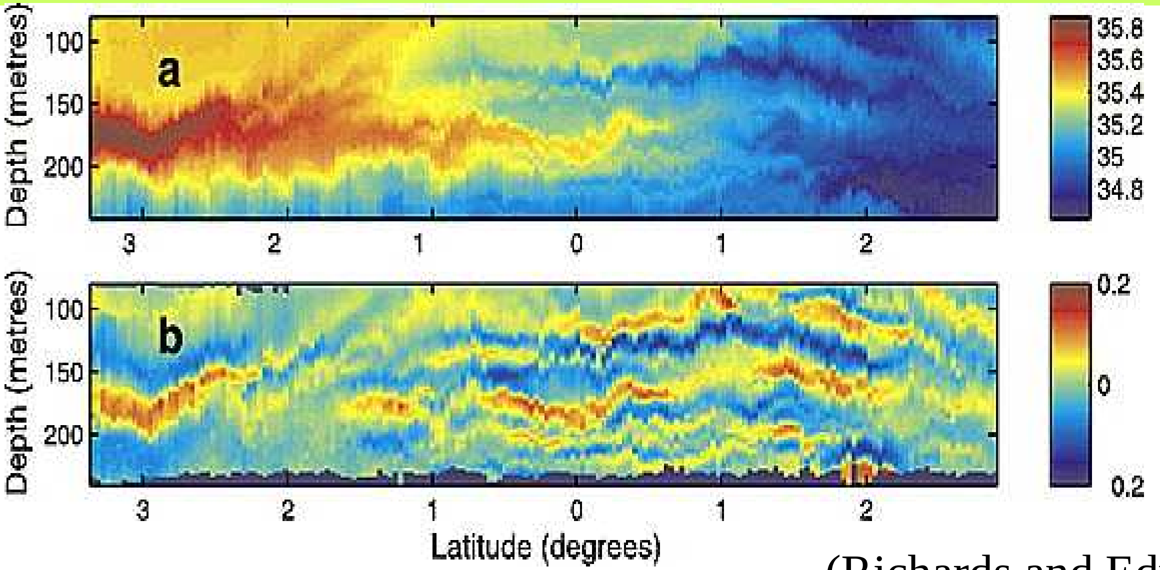
- The Pacific equatorial undercurrent (EUC) is too-intensive in the relatively high-resolution version of the SINTEX-F CGCM.
- The core speed of the EUC in the SINTEX-F is more than 20% larger than observation.

Observation



- An additional lateral mixing in the equatorial band is used to correct the magnitude of the Atlantic equatorial undercurrent (Arhan et al., 2006; Bernard et al., 2006).

Introduction



(Richards and Edwards, 2003)

- Insufficient lateral mixing associated with the interleaving process in the equatorial ocean.
- Typical vertical scales of O(20m), meridional scales of O(>30 km) and zonal scales of O(100 km).
- The process of interleaving cannot be sufficiently resolved by conventional OGCMs as well as CGCMs with coarse spatial resolution.
- Previous studies using standalone ocean model with parameterized interleaving process shows reduction of the EUC and increase in cold-tongue SST.

Purpose & Method

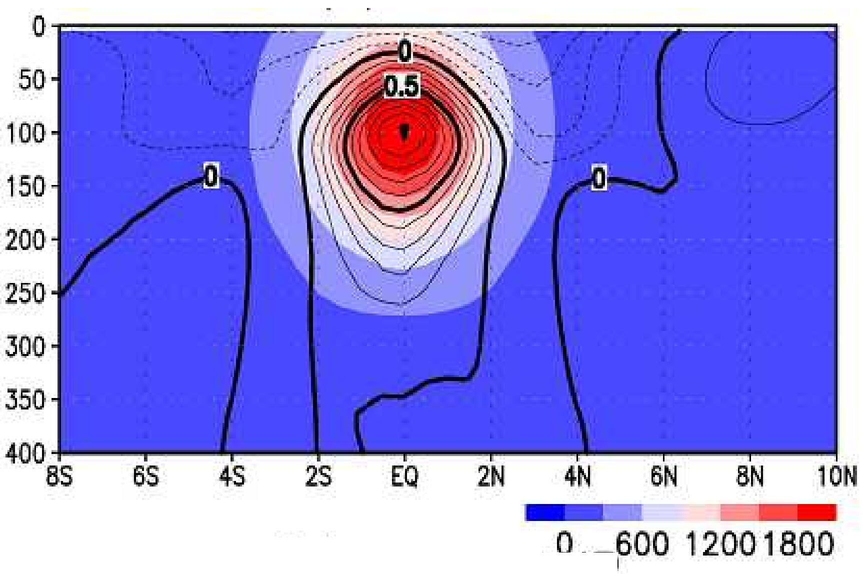
- Estimate impacts of the Parameterized interleaving process on the Pacific EUC and ENSO in a CGCM.
- SINTEX-F2

ECHAM5 (T106) + OASIS3 + OPA + LIM (ORCA05)

Parameterized Interleaving Process

$$K(lat, z) = A\exp(-(lat - lat_0)^2 / L_y^2)\exp(-(z - z_0)^2 / L_z^2)$$

$$A = 2000., \quad L_y = 2, \quad L_z = 100$$



Color: Lateral diffusivity coeff.
Contour: Zonal current climatology

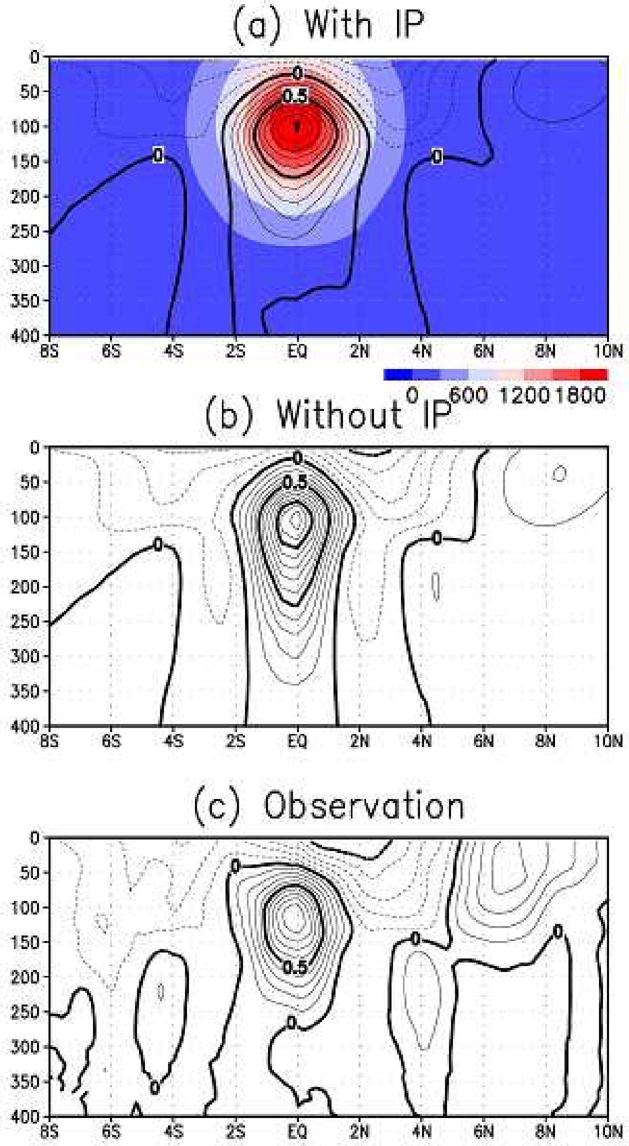
- We assume that the interleaving acts in a diffusive manner.
- Coefficient *K* is calculated by finding location (*lat*0,*z*0) of zonal current maximum in the latitude band 2S to 2N at a given longitude.
- The effect of interleaving process is chosen to be maximum on the position where the EUC is the most intense, decreasing away from the core of EUC at a lateral length scale of *Ly* (2 deg.) and a vertical length scale of *Lz* (100 m).

Experiments

- Experiment 1: No parameterized interleaving
- Experiment 2: Coeff. K is superimposed to the background diffusivity and viscosity.

- Lateral harmonic eddy diffusivity and viscosity coefficients (200 m/s2) are used as the background diffusivity and viscosity.
- In both experiments, SINTEX-F2 is integrated for 80-yr.
- The last 50-yr outputs are used for analysis.

Impact of PI on the Pacific EUC

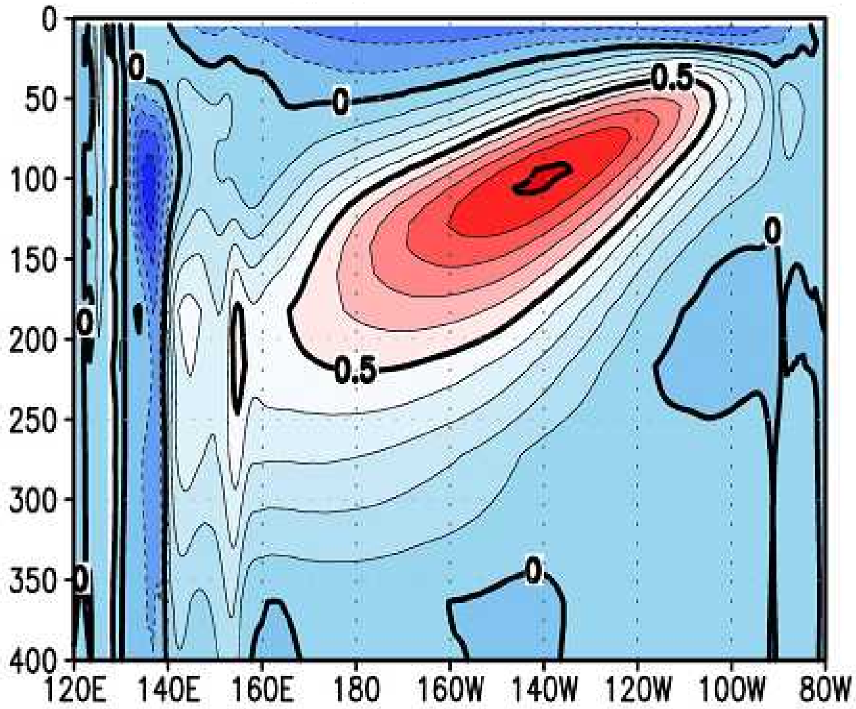


Latitude-depth section of zonal current at 140W

OBS. : ～1.0 m/s
With IP : ～1.0 m/s
Without IP : ～1.4 m/s

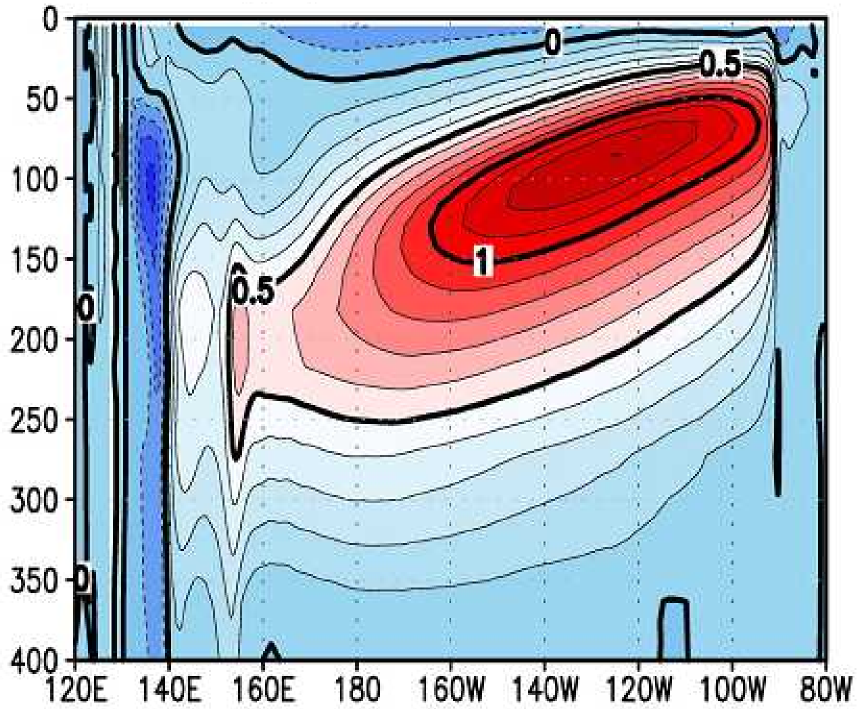
Impact of PI on the Pacific EUC

With PI



Maximum ~1 m/s

Without PI

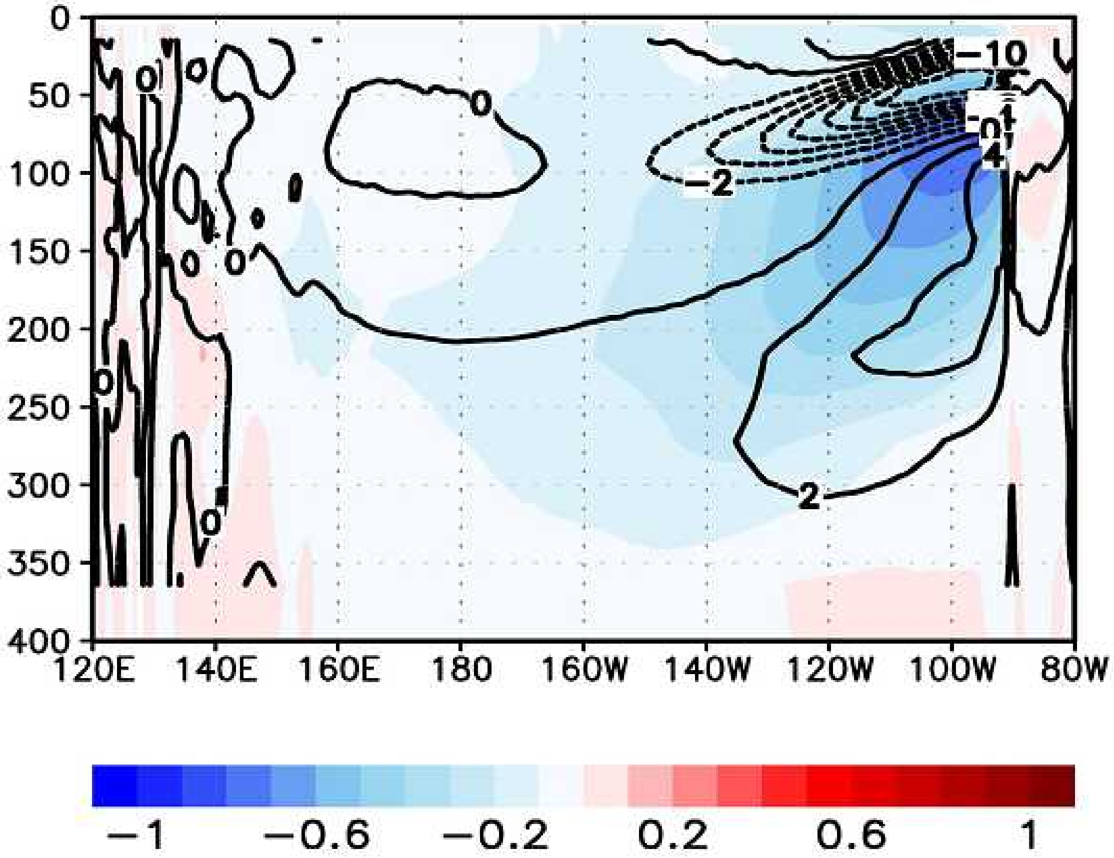


Maximum ~1.4 m/s

- The well-known jet-like structure of the EUC
- The EUC core speed simulated without PI is about 30~40% stronger than observations.
- The EUC core speed simulated with PI is much closer to the observations.

Impact of PI on the Pacific EUC

With PI minus Without PI



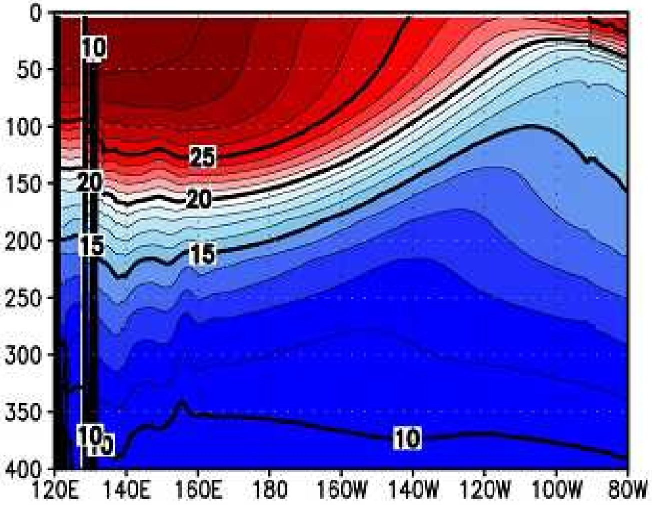
Color: Difference of zonal current speed (m/s)
Contour: Difference of vertical shear of zonal current (x10^3 m/s)

- From the 100m depth to surface layer, the vertical shear is decreased particularly in the eastern tropical Pacific, if the inverleaving mixing is parameterized.

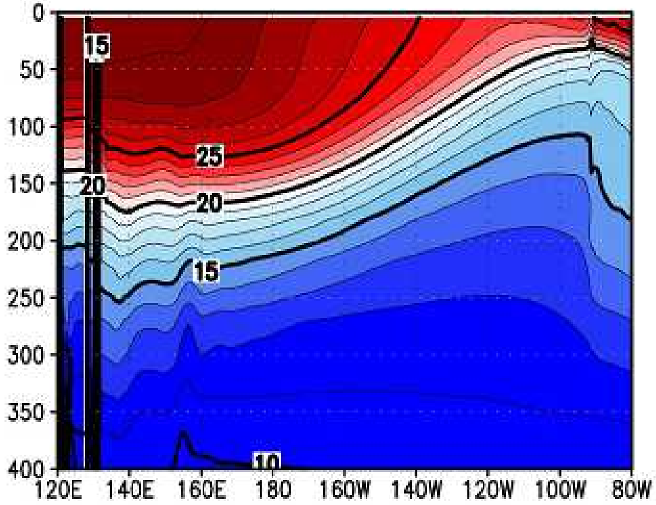
- This is consistent with *Maes et al.* (1997) who presented that a decrease of lateral diffusivity works to enhance the horizontal circulation and stronger vertical shear in an OGCM.

Impact of PI on temperature

With PI

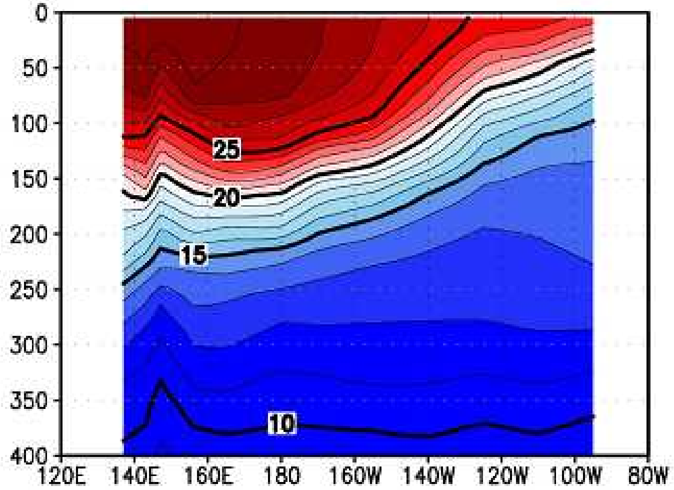


Without PI



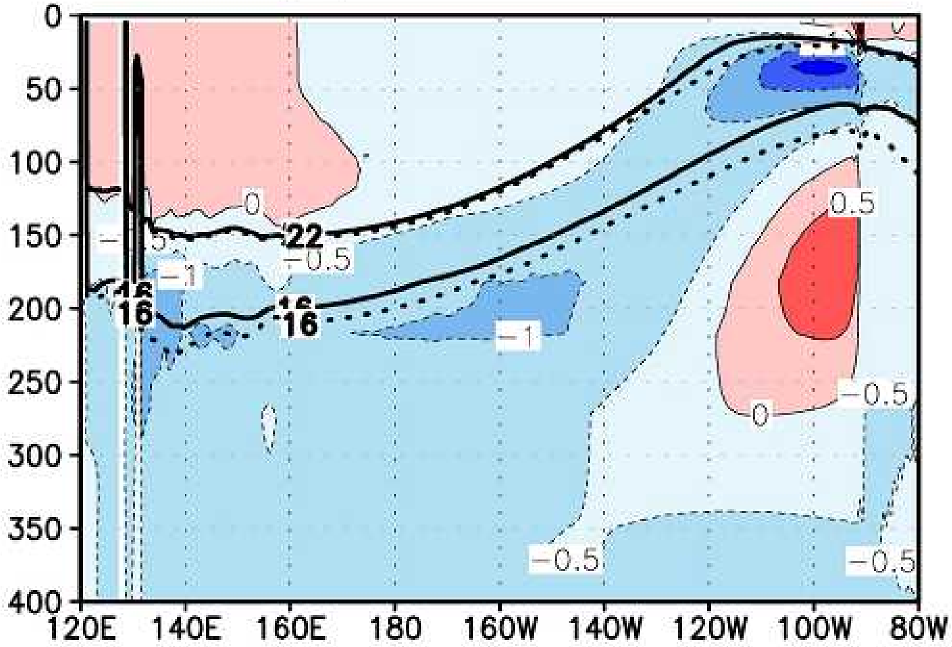
The structure of temperature is successfully simulated as observed

Observation



Impact of PI on temperature

Difference of temperature

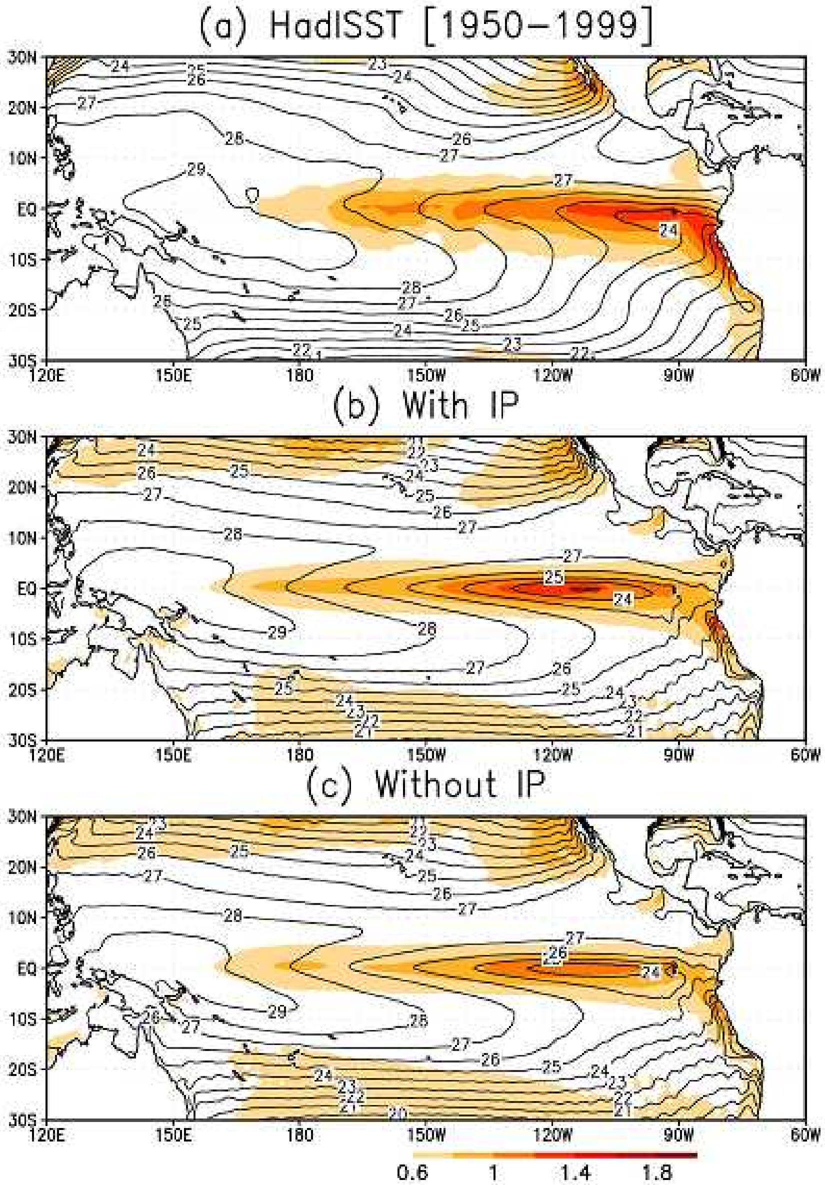


The thickness of thermocline along the equator in the Pacific becomes thinner by applying the PI.

The thinner thermocline in the presence of the PI could be explained
by the reduction of the vertical mixing.

The pattern of the difference between temperature simulated by the CGCM with the PI and that without the PI corresponds to the difference of vertical shear.

Amplitude of Temperature variation



- Amplitude of the interannual variability of SST is increased by applying the PI.
- The explained variance of the 1st EOF mode is also increased from 39% to 45%. (obs. ~52%)

Standard deviation of the monthly mean SST for 50 years.

Summary

- Parameterized interleaving process is applied to SINTEX-F2 CGCM to include the effect of lateral mixing induced by the equatorial Pacific interleaving process.
- The core velocity of the Pacific EUC is successfully reduced to observed value.
- Through the reduction of the magnitude of the EUC, the vertical shear of zonal current in the eastern equatorial Pacific is reduced. The reduction of vertical shear brings a reduction of vertical eddy diffusivity and viscosity calculated from turbulent closure scheme.
- The reduction of the vertical mixing induced sharper thermocline above the 100m depth in the eastern equatorial Pacific, and strengthening of the interannual variability of SST.

Problems

- The magnitude of the EUC in the eastern boundary of the tropical Pacific was considerably reduced.
- We may need further tuning of the PI particularly for the equatorial eastern Pacific, or improvement of the PI.