The establishment of the atmosphere-surface wave-ocean circulation coupled numerical model and its applications

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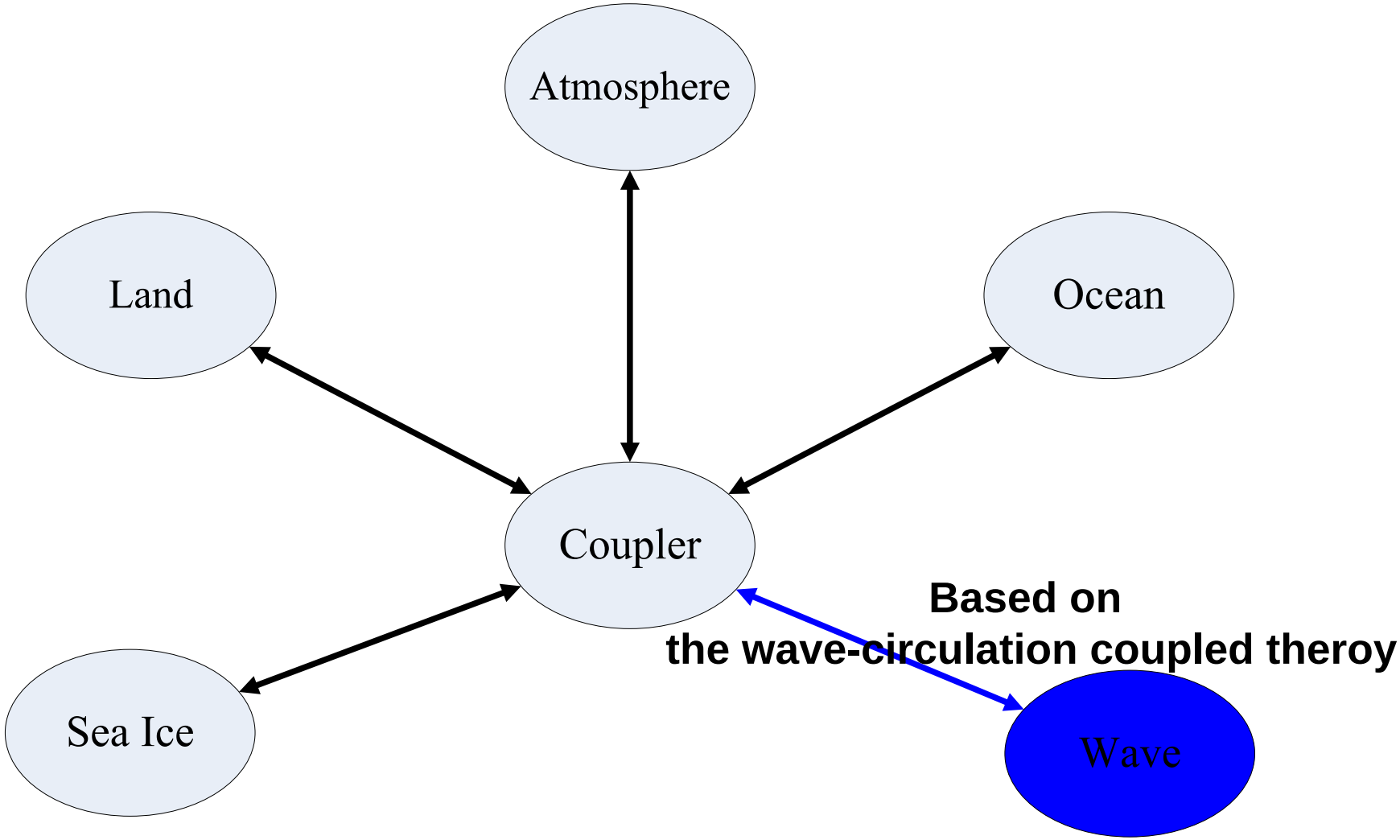
1. Introduction

The AGCM-OGCM coupled models(CGCMs) is widely used in the climate research, and can provide basically credible simulations of both the annual mean and seasonal cycle.

But there are some common problems of CGCMs without flux correction

- Too cold tongue in the tropical Pacific
- Double ITCZ in the tropical Pacific
- Reversed zonal SST gradient in equatorial Atlantic
- Weakened NINO3 index

- One important possible reason is the inaccurate reconstructed mixed layer and thermocline depth, due to the unperfected vertical mixing scheme in the OGCM.
- Yuan and Qiao(1999, 2004) propound the theory of the surface wave effect, the wave-induced mixing, and set up the wave-circulation coupled model. The results indicate that the wave-induced mixing plays an important role in the upper ocean.
- The surface wave effect is rarely considered in the CGCMs



Can the atmosphere-wave-circulation coupled numerical model be a remedy?

2. Model Description

Model linkage

1. CGCM:

FGCM-0, basically based on the NCAR-CSM1;

Atmosphere: CCM3; Ocean: L30T63

2. Surface Wave Model:

MASNUM wave number spectrum model

3. Resolution :

CCM3: T42, L26

L30T63:T63 (about 1.875º×1.875º), 30 levels;

MASNUM wave model: 2º×2º

4. Ocean vertical mixing scheme :PP,GM90

5. Simulation 70 a.

Two Experiments (51-70a)

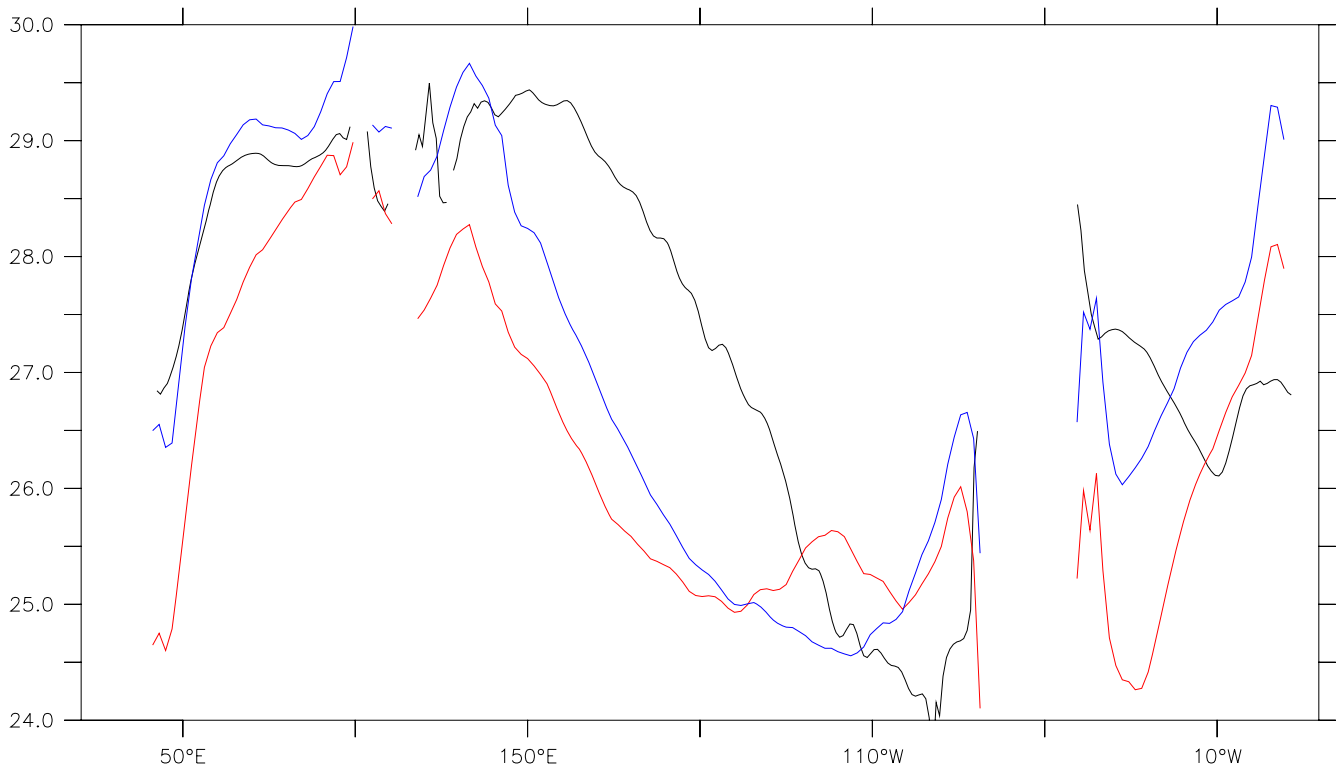
Case 1(Without wave): The original CGCM, FGCM-0,without wave-induced mixing

Case 2(With wave): MASNUM coupled model, Atmosphere-Ice-Land-Wave-Ocean coupled model, with wave-induced mixing

3. Results

	Global Ocean	Tropical Ocean (25°S ~ 25°N)	Tropical Indian Ocean	Tropical Pacific Ocean	Tropical Atlantic Ocean
Levitus Data	18.12	26.52	27.24	26.68	25.71
Without wave	17.09	25.33	25.96	25.53	23.90
With wave	18.03	26.42	26.87	26.67	25.09
Without wave - Levitus data	-1.03	-1.19	-1.28	-1.15	-1.81
With wave - Levitus data	-0.09	-0.10	-0.37	-0.01	-0.62
Without wave - With wave	0.94	1.09	0.91	1.14	1.19

Area Average SST (Annual Mean)



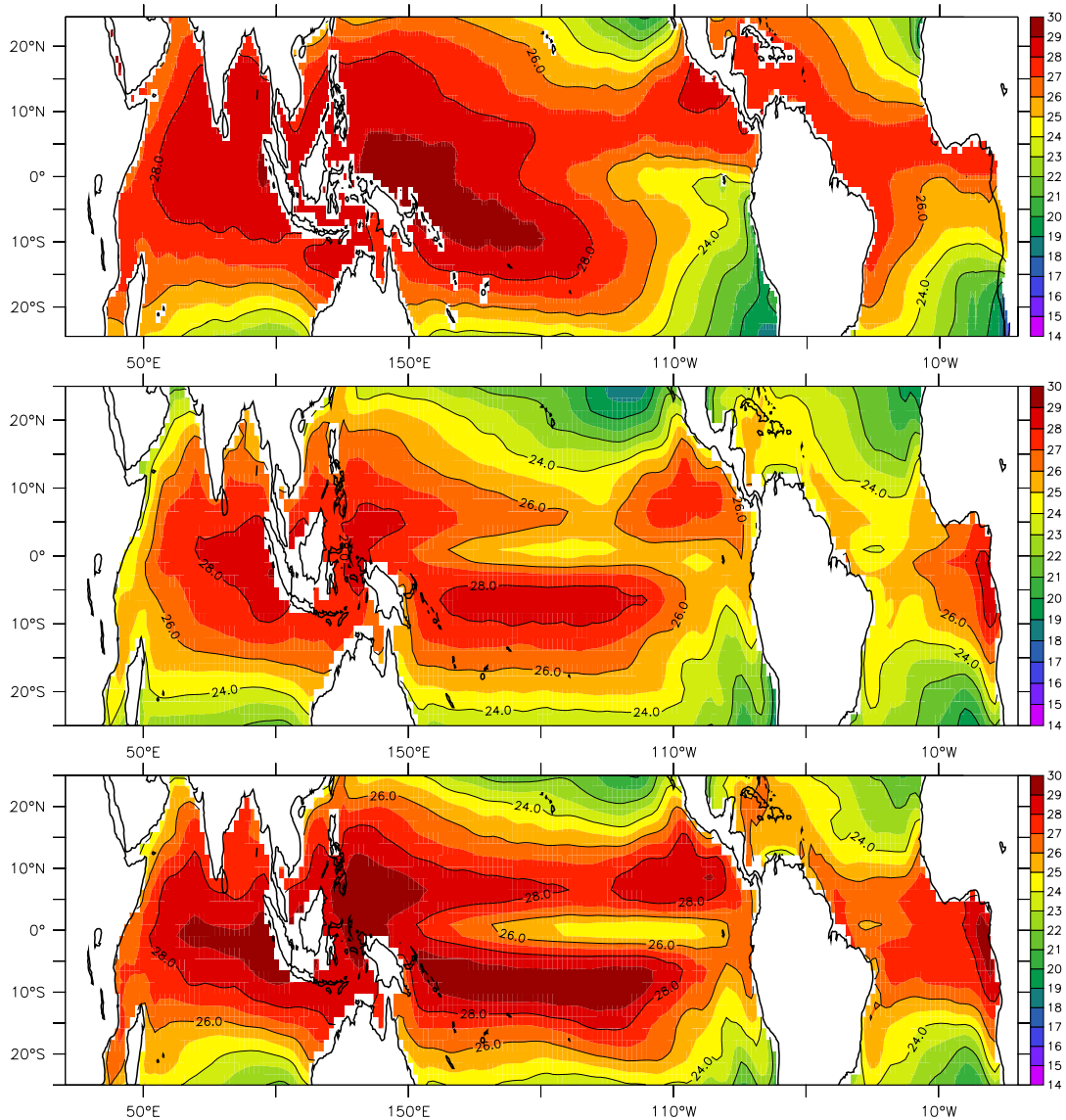
Annual mean SST for the equatorial strip $2^{o}N$~$2^{o}S$

Black line: Levitus data; Red line: without wave Blue line: with wave

Levitus data

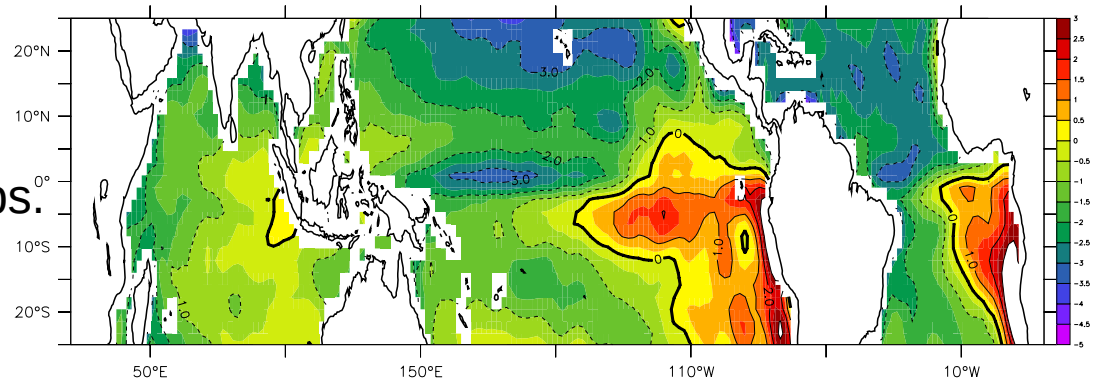
Without wave

With wave

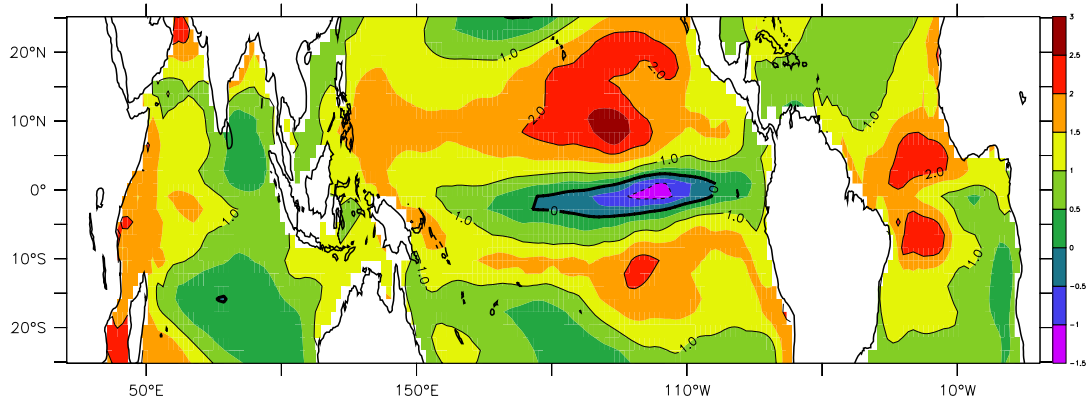


Distribution of annual mean SST(20E-380E,25N-25S)

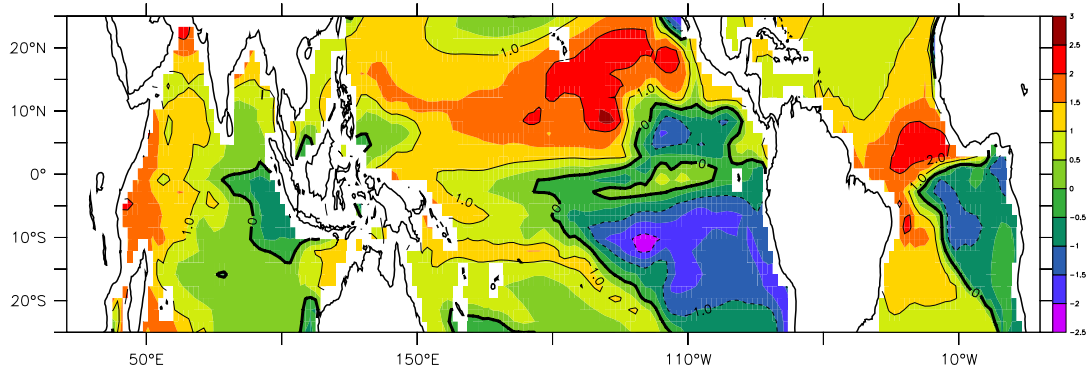
Without wave – Obs.



With wave – Obs.



Improvement



The difference of annual mean SST(20E-380E,25S-25N)

In order to illustrate the effect of wave-induced mixing clearly, we define improvement,

$\alpha_1 = \left| SST_{case1} - SST_{Levitus} \right|$, simulated SST of Case 1 relative to Levitus data;

$\alpha_2 = \left| SST_{case2} - SST_{Levitus} \right|$, simulated SST of Case 2 relative to Levitus data

$\alpha = \alpha_1 - \alpha_2$, α_1 relative to α_2;

$\alpha > 0$, positive effect with Bv;

$\alpha < 0$, negative effect with Bv.

4 Conclusion

- Compared with Levitus data, the error of global average SST decreases to 0.09℃ from 1.03℃. The error of tropical region (0-360E, 25N-25S) average SST decreased to 0.10℃ from 1.19℃, while the error decreases to 1.28℃ from 0.37℃ in Indian Ocean, 0.01℃ from 1.15℃ in tropical Pacific, and 0.62℃ from 1.81℃ in tropical Atlantic.

- The over-westward extension of the simulated equatorial cold tongue is suppressed with the incorporated wave-induced mixing in the model. The simulated SST is generally improved and the maximum improvement is more than 1.0℃. The simulated SST improvement in the north tropical Pacific is much better than that in the south tropical Pacific.

- The wave-induced mixing plays an important role in the CGCMs.
- The atmosphere-wave-ocean model could simulate mean state better, and surface wave physical processes are important for climate research and the development of the climate system coupled model.