Developing coupled ocean-atmosphere global climate model for the Earth Simulator and its preliminary physical validation

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ABSTRACT
Our objective here is to introduce coupled global climate models for the Earth Simulator (CFES) with ultra high resolution to carry out century time integration within reasonable time. It is composed of oceanic general circulation model for the Earth Simulator (OFES) and atmospheric general circulation model for the Earth Simulator (AFES). We provide fully parallelized coupling structure to transfer physical data from one component model to the other component through a coupler and back again. CFES is also able to control concurrent performance by changing the number of nodes which employed each component of atmospheric and oceanic models. In addition, we will show that interpolation scheme introduced in this coupler well conserves the physical values.

1. INTRODUCTION

Coupled Atmosphere-Ocean-Sea Ice model for Earth Simulator (:CFES) is composed of oceanic general circulation model for the Earth Simulator (OFES) with sea ice component and atmospheric general circulation model for the Earth Simulator (AFES). Both of component models have been improved computational performance on the Earth Simulator. Coupling feature might be considered as additional freedom in the interface causes disagreement with observed data, because the interface between atmosphere and ocean should be taken into account to maintain a self consistent representation. To remove causative artificial factor of the inconsistent through coupling, we have developed CFES that individual component can run independently. In this framework, each component is linked by fully parallelized coupling interface, so that each component can run independently to avoid drift due to the feedback timing. Furthermore, its computational performance efficiency of CFES has improved due to fully parallelized coupling scheme. In this paper, we will introduce preliminary results from CFES on the Earth Simulator.

2. Parallelization on coupler interface of CFES

In coupling frame work, we focused on developing self consistent interface structure between atmosphere and ocean. Ordinarily, each component was coupled with simple serial scheme as shown in Fig 2. In this coupling scheme, the systematic bias might be caused due to ordering of execution. Atmospheric component at time (t+1) is driven by the results from oceanic component at time (t). It does not allow us to model a self consistent of air-sea interactions.

We have been parallelized structure of CFES by assigning separate groups of nodes to the atmosphere and oceanic components. Each component model can run independently, so that we are able to control parallel performance with changing the number of processors for each component. At the same time, interface for coupling was also fully parallelized. This framework enables us to archive by allowing con current execution for exchanging data between AFES and OFES. This concurrency entails executing all components from time (t) to (t+1) at the same time as shown in Fig.1. A self consistent representation was provided comparing with simple serial coupling scheme.Decomposition of data exchange throughout the coupling has achieved reduction of communication costs. In ordinarily used coupling scheme, gathering/broadcasting for exchanging wasexecuted with low cost. We are now executing experiments with horizontal resolution of 106, T319, T639 under 1 to 1

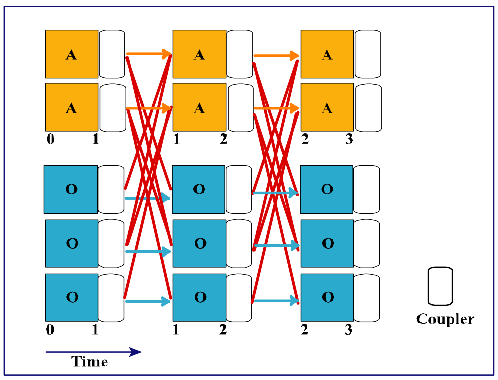

Figure 1. Structure of coupling schemes of CFES. A, O" and "coupler" represent atmospheric/oceanic, oceanic, and schemes for coupling components, respectively.

grid correspondence condition between AFES and OFES. For one month integration, they took about 11 minutes for T106 on the Earth Simulator. As wall clock time for one month 328 CPUs, about 1 hour for T319 on 1368 CPUs, and about 2.8 hours for T639 on 2808 CPUs of the Earth Simulator.

3. Preliminary results

From results of various resolution experiments, we show preliminary results of CFES with T106 after two years integration on the Earth Simulator. Fig.2. and Fig.3 present SST and SSS, respectively. Although integration term is too short to validate its physical performance, those distributions are reasonable and it shows that coupling is executed with conserved flux values on the whole region. Furthermore, we present annual averaged precipitation of CFES with T106 in Fig.4. In Fig. 5, vertical distribution of temperature on equator band between 2 degree of North and 2 degree of South is showed. Those distributions are also acceptable at present state.

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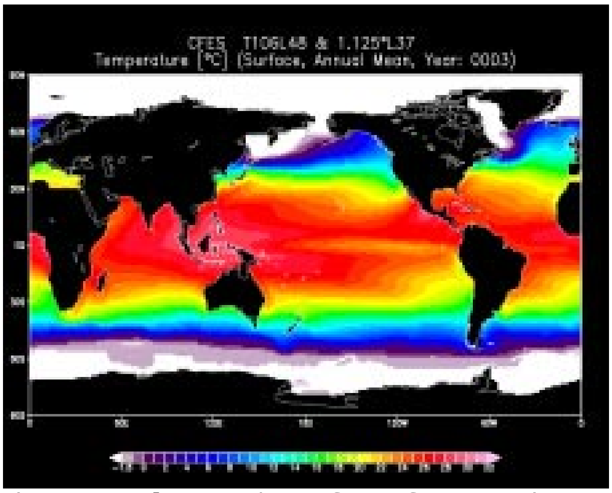

Figure 2. Annual averaged SST of CFES after 2 years integration of CFES with T106 horizontal resolution.

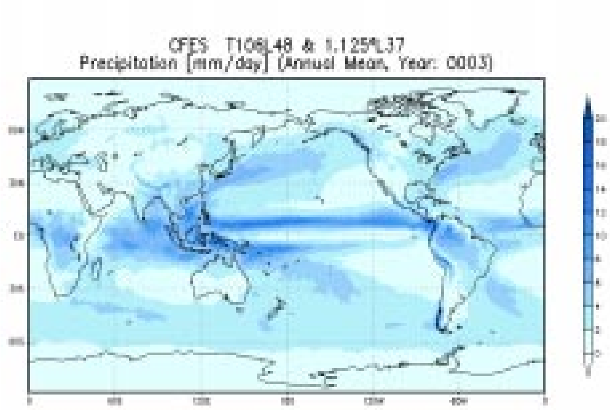

Figure 4 Annual mean of precipitation after 2 years integration of CFES with T106 horizontal resolution.

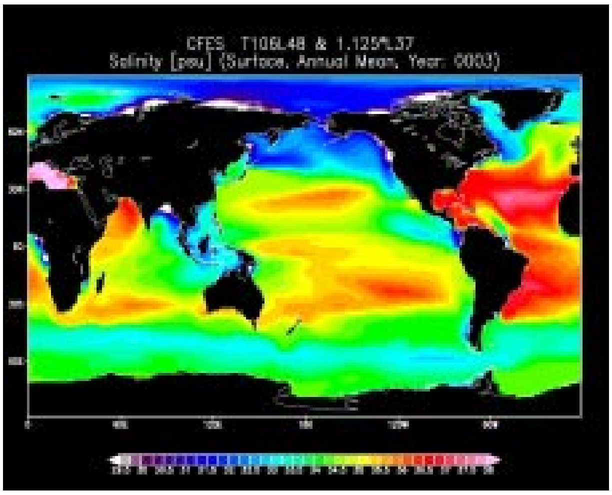

Figure 3. Annual mean of SSS after 2 years integration of CFES with T106 horizontal resolution.

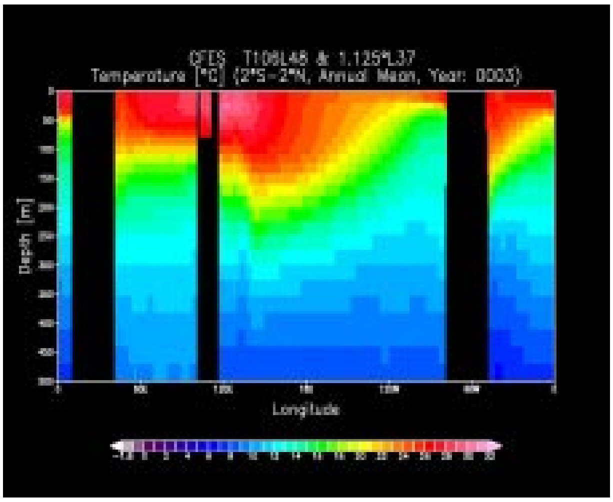

Figure 5. Annual averaged distribution of temperature on equator of ocean after 2 years integration.