Variability of Mesoscale Eddies in the Pacific Ocean Simulated by an Eddy Resolving OGCM of 1/12°

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ABSTRACT

The mesoscale eddy field in the North Pacific Ocean, simulated by a high resolution eddy-resolving OGCM (1/12° horizontal resolution), was analyzed, and compared with satellite altimetry data of TOPEX/Poseidon. High levels of eddy kinetic energy (EKE) appear near the Kurosho, North Equatorial Current (NEC), and Subtropical Countercurrent (STCC) in the western part of the subropical gyre. In particluar, it was found that the EKE level of the STCC has a well-defined annual cycle, but no such distinct annual cycle of the EKE exists in any other zonal current of the North Pacific Ocean.

1. INTRODUCTION

Almost everywhere in the open ocean the kinetic energy of the flow field is dominated by mesoscale variability, with spatical scales varying roughly from some 10 km in subtropical region to a few 100 km in the tropics. The potential impact of these mosescale eddies on the mean properties of the ocean with the associated large-scale transports of heat, energy, mass, and biogeochemical tracers has been the subject of interest to physical oceanographers for a long time. However, only recently it has become feasible to run an ocean general circulation model (OGCM) with the fine resolution enough to resolve mesoscale features at mid and high latitudes.

In the present study, we analyzed the characteristics of mesoscale eddies simulated by an high-resolution OGCM of 1/12°, taking advantage of the Earth Simulator (ES) that was developed in 2002 in Japan. We investigated the spatial and temporal variation of EKE in the Pacific Ocean, and compared the results with the altimetry data the TOPEX/Poseidon mission (October 1992 – December 1997).

2. MODEL

RIAMOM (RIAM Ocean Model) used in this study is the primitive general ocean circulation model with a free surface, which is developed by Lee and Yoon [1] at Research Institute for Applied Mechanics (RIAM). The model covers from 95°E to 70°

W in longitude and from 50°S to 65°N in latitude. The horizontal grid interval is 1/12° in both latitudinal and longitudinal directions and vertical layers are 70 levels. The subgrid-scale vertical mixing process is improved by the Noh scheme [2]. The model was integrated from a state of rest with annual mean temperature and salinity distribution by Levitus, and forced by NCEP wind stress climatology during the period from 1979 to 2001.

3. PARALLEL COMPUTATION

The simulation was carried out in ES. ES is a highly parallel vector supercomputer system of the distributed-memeory type, and consists of 640 processor nodes (PNs). Each PN is a system with a shared memory, consisting of 8 vector-tyoe arithmetic processrors, a 16 GB main memory system, a remote access control unit, and an I/O processors.

The domian decomposition of the model for the MPI process was made two-dimensionally in the horizontal direction. The whole values calculated at each CPU were communicated in the buffer zone. The model used 120 nodes (960 CPU) of ES, and one year integration needed 10 hours of total CPU time.

4. RESULT

Figure 1 compared the rms sea surface height (SSH) in the Pacific Ocean, obtained from the OGCM and the satellite data. The SSH h is related to the horizontal velocity of mesoscale eddies $\mathbf{u}_g$ by geostrophic balance, i.e., $\mathbf{u}_g = (g/f)\mathbf{k} \times \nabla h$. Comparison reveals a good agreement not only in the spatial pattern of EKE but also in the magnitude, although the EKE in the Kuroshio region is somewhat exagerated. High levels of EKE appear near the Kurosho, North Equatorial Current (NEC), and Subtropical Countercurrent (STCC) in the western part of the subropical gyre. Note that the simulated EKE were much weaker than that of observation in the case of a lower resolution OGCM [3].

Qiu [4] found that the EKE of the STCC has a well-defined annual cycle with a maximum in April/May and a minimum in December/January with its peak-to-peak amplitude exceeding 200 cm^2s^{-2} but no such distinct annual cycle is found in any other current zone. Figure 2 compares the seasonal variation of EKE in the STCC, NEC and Kuroshio Extension (KE) regions. A good agreement is observed in the STCC region, expcept in Januray/February, where the simulated EKE is higher. On the other hand, the agreement is not so good in the regions with no clear annual cycle such as KE and NEC.

Qiu [1] also suggested a theory explaining the annual cycle of EKE in the STCC based on the baroclinic instability process. Further analyses of the present OGCM data, including the subsurface structure, will clarify the mechanism.

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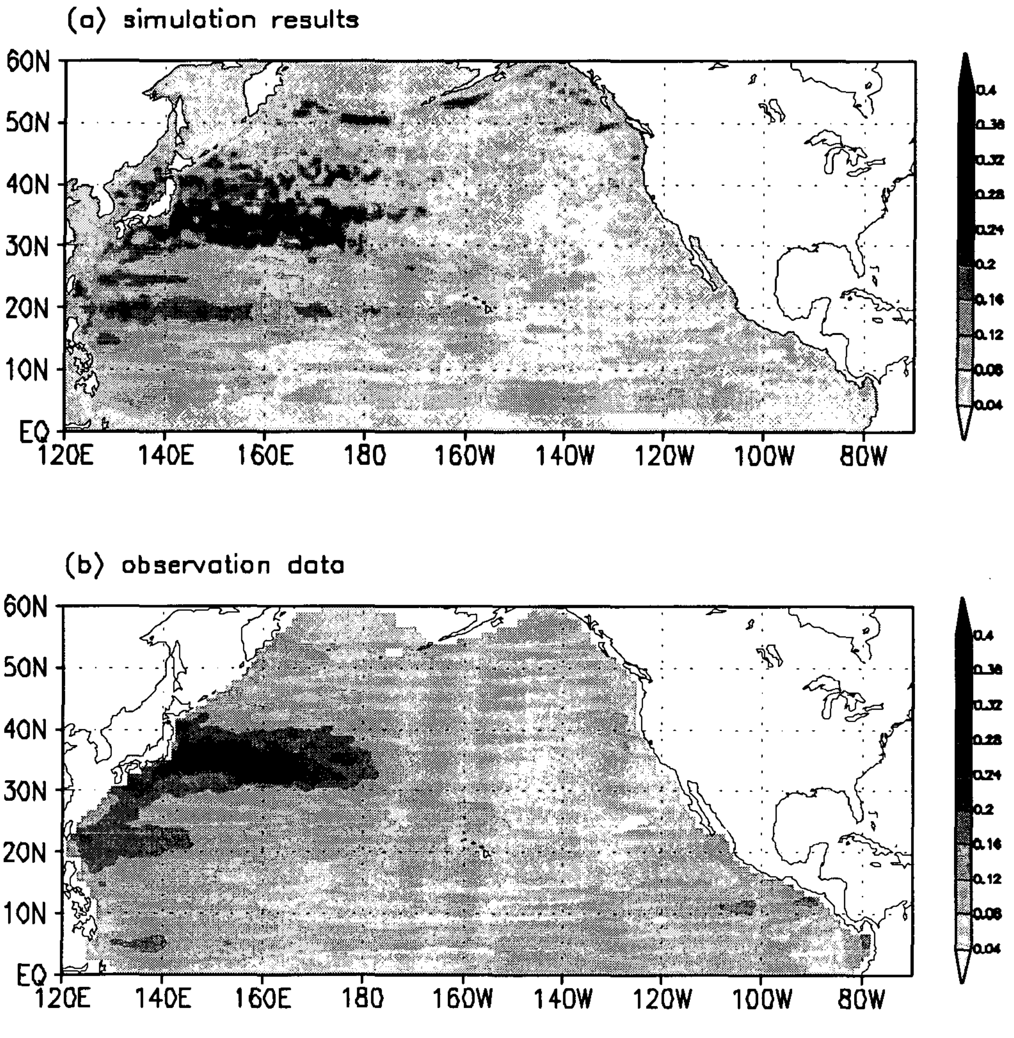

Fig. 1 The distribution of the rms SSH in the North Pacific Ocean: (a) simulation results, (b) observation data

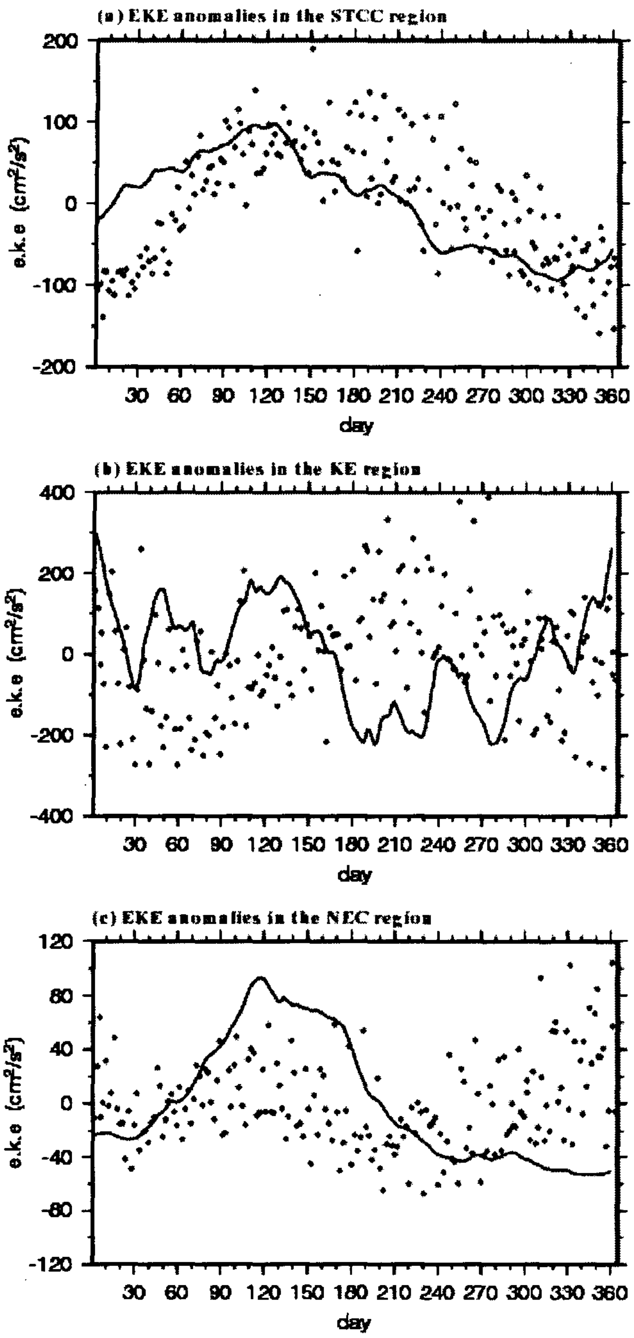

Fig. 2 Seasonal variations of EKE inferred from the simulation result (solid line) and the observation data (scattered dots). The observation data was obtained during the period October 1992- December 1997: (a) the STCC region (19° – 25° N, 135°E – 175°W), (b) the KE region (32° – 38° N, 140°E – 170°W), (c) the NEC region (10° - 16° N, 135°E – 175°W).