Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

MIS021-12 会場:202 時間:5 月 22 日 12:00-12:15

海洋によって誘起される黒潮続流上流の長周期変動
Long-term variations of the upstream Kuroshio Extension based on self-sustained dynamic modes.

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1.Introduction

Variations of upstream KE jet exhibits two flow patterns (Qui and Chen, 2005). The first pattern is quasi-stationary meanders of two bumps with intensive southern recirculation gyre (first mode). Another flow pattern is unstable and shows high-amplitude meanders with a weakened southern recirculation gyre (second mode). The upstream KE jet varies between the first mode and the second mode with decadal time scales.

Many studies have pointed out the importance of nonlinearity in the ocean by itself to induce the decadal time scale changes (Primeau and Newman 2008, Shimokawa and Matsuura 2011), which is main topic of this study. Firstly, using self-organaization map (SOM) analysis we examine the variations of upstream KE jet in more detail and variation pattern were sorted out. Secondly, we make a reconstruction of attractor of Sea-Surface Hight (SSH) to reveal whether this phenomenon is the chaotic one or not.

Moreover, we investigate this phenomenon by simulating an OGCM (MOM3) of the North Pacific Ocean forced by seasonal climatological winds for 30 years.

2.Used data and methods

SSH data of MOVE/MRI.COM-WNP were used to analyze the characteristics of KE jet. The used data are averaged over 10 days from early January 1993 to late December 2005. The domain of MOVE/MRI.COM-WNP covers over the sea areas of 117E - 160W, 15N - 65N in the North Pacific. The horizontal resolution is 0.1x 0.1.

SSH are extracted in the ocean area of 141E - 153E , 30N - 40N to carry out SOM analysis and to estimate the mean strength of the upstream KE jet. The size of SOM in our analysis is 169, that is 13 x 13 matrix. We make a reconstruction of attractor of the time series of SSH anomalies by transforming observed time series into delayed time series.

Moreover, we simulated the North Pacifoc Ocean to confirm the long-term variations of the upstream KE based on self-organized dynamic modes. The OGCM used in this study is the GFDL Modular Ocean Model version 3 (MOM3). Computational domain covers the North Pacific (110E-75W, 20S-60N). The model has a horizontal resolution varying from 1/12 around Japan (125E-160E, 20N-50N) to 1/2. The model topography is based on 1/12 ETOPO5 data.

3. Result

The time series of strength of upstream KE jet obtained from ocean data assimilation corresponds well to Topex/Poseidon altimeter results of Qiu and Chen (2005). The upstream KE jet was strong in 1993-94, weakened to 1997 , and strengthened to 2004 again.

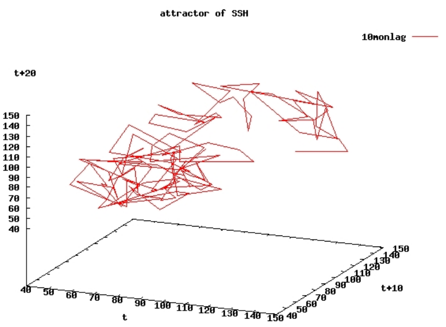
SOM analysis revealed two long-term disparate variation patterns. The first is the stable pattern with strengthening southern recirculation. The second is the unstable pattern with weak southern recirculation. Patterns in 1993-94 and 2002-2005 were sorted out as the stable pattern and pattern in 1996-2001 was sorted out as the unstable pattern.

As a result of a reconstruction of attractor, an obtained pattern could not be recognized as the strange attractor completely. However, it was spatially divided into two parts.

The interannual variability appeared in SSH data obtained from a simulation of the OGCM (MOM3). In particular, the variability in the simulation showed strengthening/weakening of southern recirculation and north-south shift of upstream KE jet axis which confirmed by analyzing MOVE/MRI.COM-WNP.

4. Discussion

It is clear that the variability in strength of upstream KE jet corresponds to the variability in stable-unstable pattern. In particular, when upstream KE jet is stable (unstable), the strength of upstream KE jet is strong (weak). Obtained attractor which was spatially divided into two parts indicates that the time series of strength of upstream KE jet is not completely random, but it possess certain unique behavior. The results of OGCM simulation indicate that the nonlinearity in the ocean itself affects on variations between stable and unstable of the upstream KE jet and north-south shifts of KE jet axis.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