SSH wavenumber spectra in the North Pacific from a high-resolution simulation

Hideharu Sasaki[1*], Patrice Klein[2]

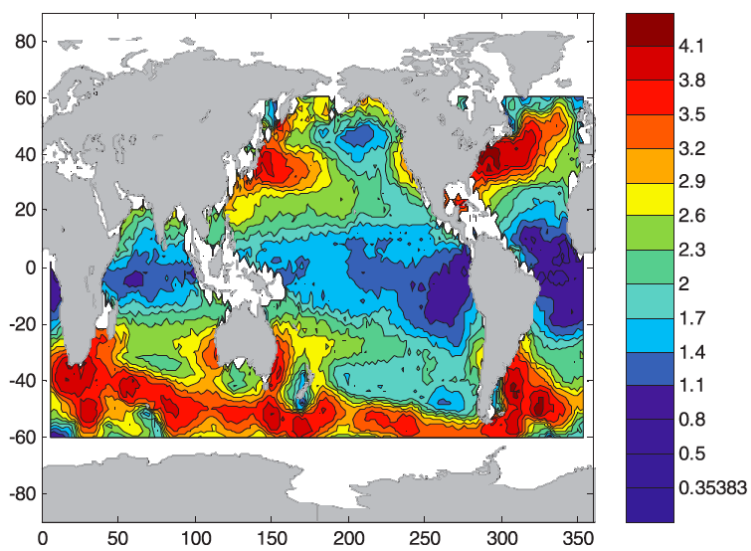
1: Earth Simulator Center/JAMSTEC, 2: L.P.O./IFREMER *E-mail: sasaki@jamstec.go.jp

INTRODUCTION

- Mesoscale geostrophic eddies (O(100-300km)) are the largest reservoir of the kinetic energy (KE) in the oceans (Ferrari and Wunsch 2009).
  →The mechanisms that distribute and control the KE have not yet been well understood.
- The distribution of the sea surface height (SSH) and KE over a range of spatial scales
  → Underlying processes of oceanic mesoscale turbulence such as those from quasi-geostrophic (QG; Hua and Haidvogel 1986) and surface quasi-geostrophic (SQG; Held et al. 1995) turbulence theories.
- Satellite sea surface height (SSH) data are useful to observe KE distribution in the global region (e.g., Le Traon et al., 2008, Xu and Fu, 2011).
- SSH spectral slope shallower than K^-3 is observed in low eddy kinetic energy (EKE) region in the scale range of 70-250km estimated from Jason-1 altimetry (Xu and Fu, 2011).

Question: If a shallow SSH spectral slope persists for smaller scale, this would suggest very high EKE at small scales.
→ SSH wavenumber spectrum at wavelengths shorter than 100km are examined in a realistic high-resolution simulation.

Map of spectral slope of satellite observed SSH wavenumber spectral in the range of 70-250km (Fig. 2 of Xu and Fu, 2011)

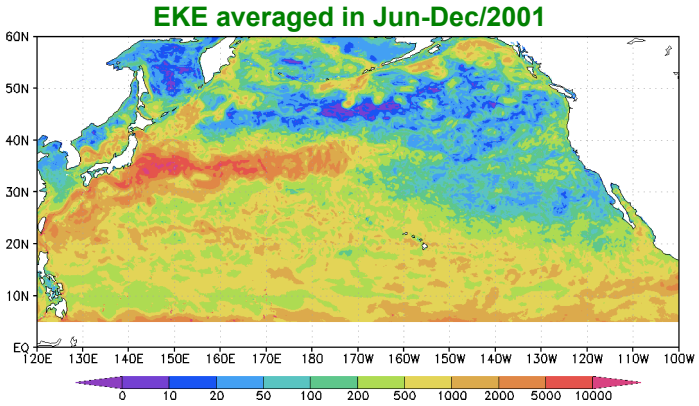


HIGH-RESOLUTION SIMULATION

Model Description
Model: OFES (Masumoto et al., 2004, Komori et al., 2005)
Domain: North Pacific (20S-68N, 100E-70W)
Resolutions: 1/30° Number of vertical level: 100 (60 layers in the upper 500m)
Horizontal mixing: Bi-harmonic
Vertical mixing: Noh and Kim (1999)
Forcing: 6 hourly reanalysis data of JRA-25(Onogi et al., 2007)
Initial condition: Outputs from 0.1° hindecast simulation on JAN/01/2000

JAN/01/2000 — JAN/01/2002
JUN/01～DEC/31 in 2001

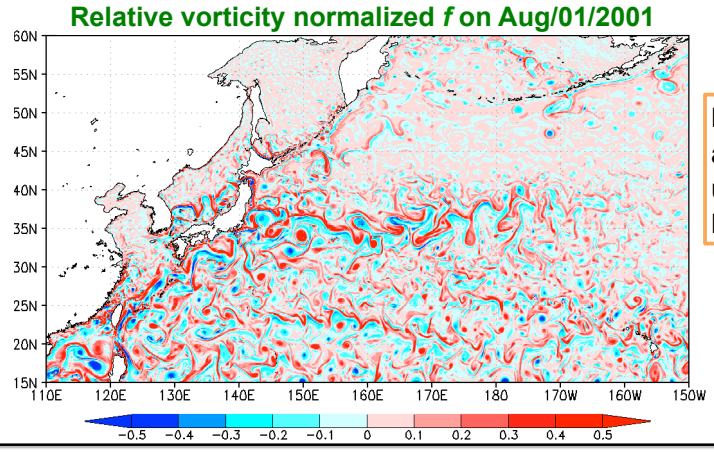
EKE averaged in Jun-Dec/2001



Low EKD:
East of 170W, 20-50N,
East of 160E, 40-50N.
High EKE:
Other regions

Comparable to satellite observations (e.g. Chelton et al. 2001).

Relative vorticity normalized *f* on Aug/01/2001

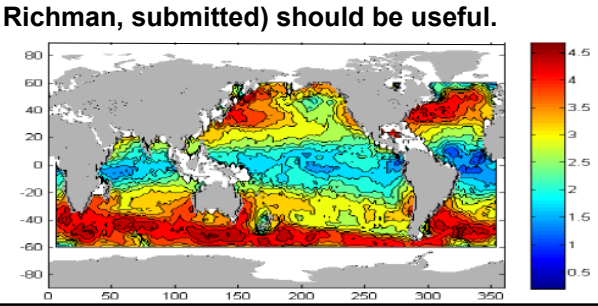


Not only mesoscales but also submesoscales are ubiquitous in the North Pacific.

SUMMARY and DISCUSSION

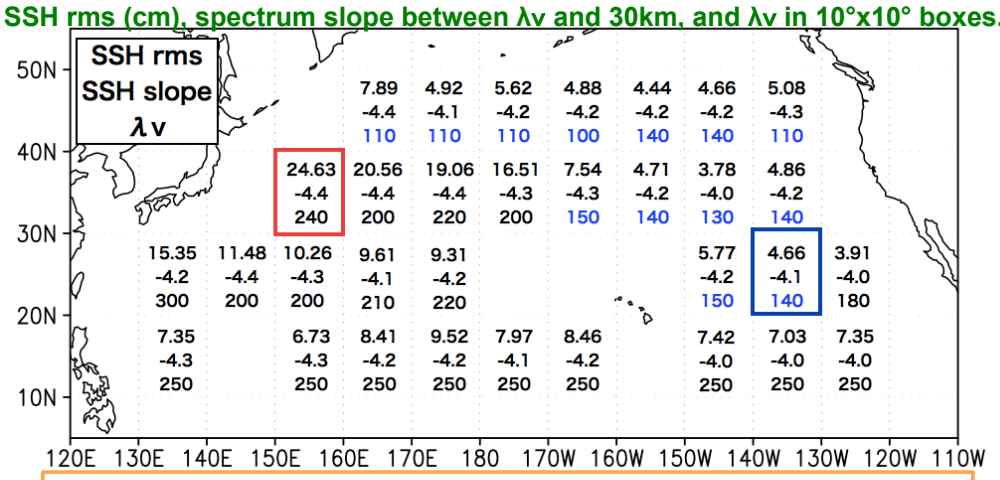
- In all, high and low, EKE regions, the SSH spectral slopes almost follow a K^{-4} or slightly steeper law, observed in particular for scales smaller than 100km.
- Such slope close to SQG theory and the associated inverse KE cascade highlight the dynamical impact of small-scale process on the larger-scale ones.
- Spectral slope of satellite observation removing measurement noise became much closer to that in this simulation. (see a below figure)
- Further space mission (SWOT), high-resolution in-situ observations such as radar observations (e.g. Kim et al., 2011) and realistic simulation with even higher resolution with internal tides (e.g. Richman, submitted) should be useful.

Modified spectral slope of satellite observed SSH removing measurement noise (Personal comm. by Dr. Fu)



RESULTS

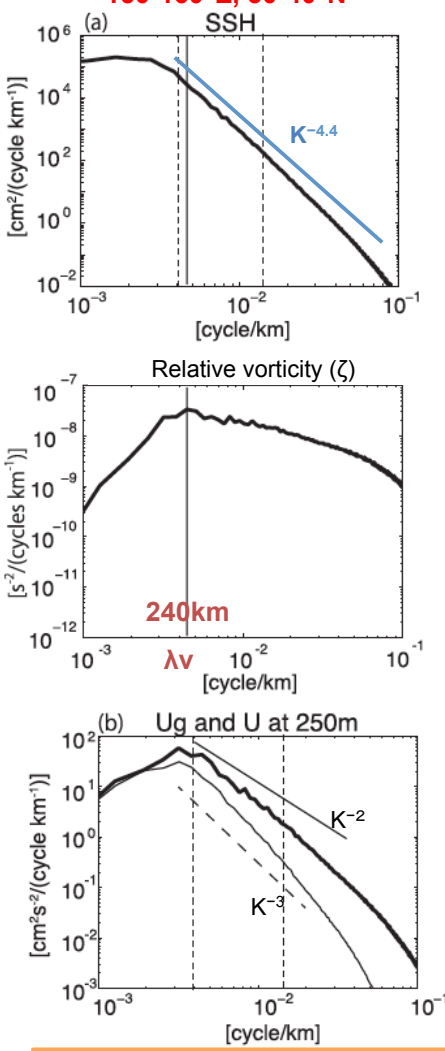
SSH rms (cm), spectrum slope between λv and 30km, and λv in 10°x10° boxes.



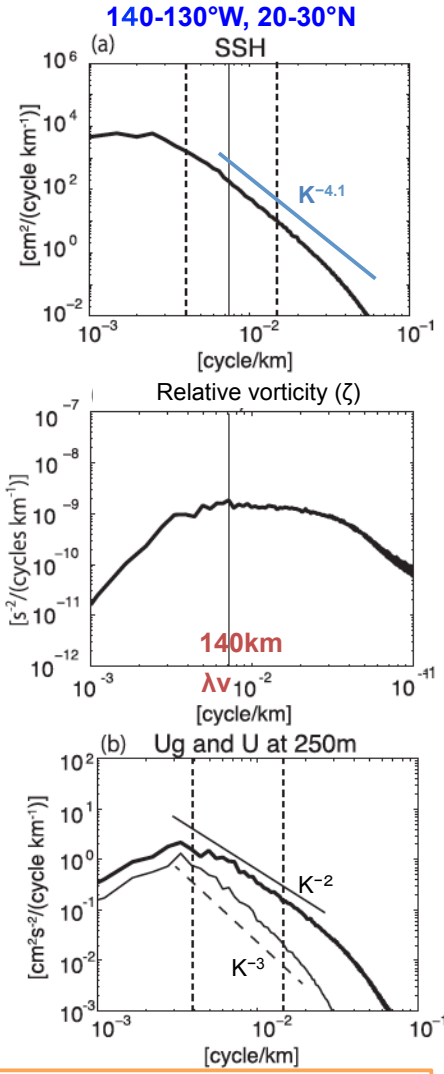
- k^{-4} or steeper SSH slope expected from surface quasigeostrohphic (SQG) theory is observed in the both high and low EKE regions.
- λv in low EKE region (≦150km) < λv in high EKE region (200-300km)
  (λv; Wavelength with the peak of relative vorticity spectrum)

Wavenumber spectra of SSH (top), relative velocity (middle), and geostrophic velocity (thick curve) and velocity at 250m (thin curve) (bottom)

150-160°E, 30-40°N



140-130°W, 20-30°N



QG like regime at 250m depth and SQG-like regime at surface are consistent with previous studies (Lapeyre and Klein, 2006; Klein et al., 2008).