GENERATION OF LOW-FREQUENCY SPICINESS VARIABILITY IN THE THERMOCLINE

A THESIS SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY OF HAWAI'I IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

IN

OCEANOGRAPHY

DECEMBER 2009

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ABSTRACT

Spiciness, or density-compensating temperature and salinity variability, can originate in the extratropics, and affect decadal climate after reaching the equator via advective pathways. We study the generation of a prominent density-compensated salinity signal in the thermocline of the Northeast Pacific, using an eddy-permitting regional model hindcast of 1950–2007. The signal is exceptionally smooth, with a -4 spectral slope for frequencies greater than 0.2 cpy. The signal is so smooth because it is dominated by anomalous geostrophic advection. A Markov model forced by an index of the large-scale sea-surface height (SSH) gradient reproduces the phase of the signal and the -4 spectral slope.

We develop a simple theory for anomalous geostrophic advection, which can be represented by coupling two Markov models. The first is for the wind stress curl forcing the baroclinic pressure field; the second is for the baroclinic pressure controlling advection of salinity. This "double integration" of atmospheric forcing results in the -4 slope for salinity. Nearly all variance is at frequencies below 0.2 cpy. Anomalous advection thus provides a null hypothesis for interannual to decadal climate variability: the double integration of stochastic Ekman pumping in the extratropics efficiently generates low-frequency spiciness variability in the thermocline, which then propagates to the equator. No feedbacks on the extratropics are invoked.

The salinity spectral slope is wavenumber-dependent because the synoptic eddy field is superimposed on the anomalous advection signal, which is coherent at a larger scale than individual eddies. At high wavenumbers the influence of eddies whitens the salinity spectrum, but for low wavenumbers (wavelengths greater than ~300 km) the high-frequency variability cancels and the -4 slope of anomalous advection emerges. The implication is that large-scale measurements are needed to observe the -4 slope signal.