Book: Dynamical Oceanography
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Chapter: 8, Exercise: 8.4: Rossby waves in the Pacific
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Rossby waves propagate westwards and can be observed at midlatitudes with altimeters. In the figure below (source http://topex-www.jpl.nasa.gov/), measurements of sea surface height anomalies (in cm) are plotted as a function of time along three latitudes in the Pacific (at 20°N, 32°N and 39°N, respectively), see the on figure p 197.

a. Provide an estimate of the phase speed of the Rossby waves in these figures.

Consider, for example, the bottom panel. The anomaly in sea surface height located at 180°W at January 1993 is located at 120°W about 800 days later. As this anomaly travels along 39°N, the total length of the path is

$$L = \frac{60}{360} 2\pi r_0 \cos 39^\circ \approx 5127 \text{ km}$$

The phase speed C is given by

$$C \approx -\frac{5 \times 10^6}{800 \times 24 \times 3600} = -0.07 \text{ m/s}$$

b. Calculate the dimensional phase speed of a Rossby wave with a zonal wavelength of 5000 km and with an infinite meridional wavelength in a constant density layer of water with a depth H_0 = 3 km at (i) 10°N and (ii) 60°N.

It seems that $\lambda = 2500$ km is a more appropriate choice for the anomaly picked in question a). For a barotropic wave with meridional wavenumber $l = 0$, the wave speed is given by

$$C = \frac{\sigma}{k} = -\frac{\beta_0}{k^2} = -\frac{\beta_0 \lambda^2}{4\pi^2} \approx (i) - 3.6; (ii) - 1.8 \text{ m/s}$$

for $\beta_0 = 2\Omega \cos\theta_0 / r_0$ $(\text{ms})^{-1}$. The wave speed decreases with latitude according to the changes in β_0.

c. Are the waves in the figures barotropic or baroclinic Rossby waves?

If it is the signature of *purely* zonally moving waves (they could also be eddies) then it is very likely that they are baroclinic since the wave speed is too small for barotropic waves.