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Rossby Waves, Evaporation and the Interannual and Decadal Variability of Salinity and Temperature off California

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Previous work has shown that large-scale interannual Rossby waves propagate westward from the coast off southern California and that the large-scale anomalous alongshore velocity field is proportional to the time derivative of the interannual sea level anomaly. Using these results, theory is developed for interannual perturbations to a mean density field that varies both vertically and alongshore like that for the California Current region off Southern California. Because both the anomalous vertical and alongshore currents are proportional to the time-derivative of the interannual sea level, the theory suggests that the anomalous currents associated with the Rossby waves, acting on the mean temperature field, should induce temperature fluctuations proportional to the anomalous dynamic height. The alongshore and vertical advection contribute to the temperature fluctuations in the same sense, a higher than normal sea level, for example, resulting in downward and poleward displacement of warmer water and a local higher than normal temperature. Near the surface alongshore advection dominates vertical advection but vertical advection dominates near the thermocline and below. Correlation of observed temperature and dynamic height anomalies from the California Cooperative Oceanic Fisheries Investigation (CalCOFI) data is positive, consistent with the theory. The correlation is highest ($r \approx 0.8$) near 100 m depth in the thermocline. The gradual fall in correlation in deeper water is likely due to a fall in signal to noise ratio with depth as the predicted signal and the observed temperature anomalies become small. The correlation also falls toward the surface but over much of the region is still between 0.5 and 0.6, suggesting that the advection mechanism is

a major contributor to the temperature anomalies there.

The anomalous Rossby wave currents, acting on the mean background salinity gradient, also induce salinity anomalies that are proportional to the dynamic height anomalies but opposite in sign. Vertical advection dominates, a (say) higher than normal dynamic height corresponding to a downward displacement of lower salinity water and a local negative salinity anomaly. Consistent with the theory, the correlation of observed CalCOFI salinity and dynamic height anomalies is negative, being largest in magnitude ($r \approx -0.8$) at depths 100-200 m. In deeper water the correlation magnitude decreases as the predicted and observed salinity anomaly signal becomes small. The sharp fall in correlation in water shallower than 100 m is not due to a fall in anomaly amplitude, but rather is at least partly because of anomalous evaporation which drives an interdecadal surface ocean salinity response. This signal is closely approximated by the easily monitored surface salinity at the coast.