HEAT STORAGE AND ADVECTION IN THE NORTH PACIFIC OCEAN

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By

Karl Hans Bathen

Dissertation Committee:

Klaus Wyrtki, Chairman
Carl Adams
Richard Barkley
Brent Gallagher
Richard Jones

ABSTRACT

An analysis is made of the processes maintaining the seasonal heat storage in the 0 to 250 meter surface layer of the North Pacific Ocean. Approximately 140,000 bathythermograph observations taken in the Pacific Ocean from 10° South latitude to 70° North latitude are used. Mean temperature profiles are computed for each month and are numerically integrated to find the total heat stored in the 0 to 250 meter surface layer. The monthly maps show the heat storage decreases eastward and northward from a maximum in the Western Tropical Pacific to a minimum in the Bering Sea. The seasonal amplitude of the heat storage was found to be greatest around Japan, off the coast of Alaska, and south of the Hawaiian Islands. The seasonal amplitude was also found to exceed the amplitude of the net surface heat exchange over most of the ocean. Using the Laplacian of the heat storage, mixing is found to contribute between 10% and 38% to the local monthly change in heat storage where the Kuroshio and Oyashio meet, west of Vancouver Island, and south of the Aleutian Islands. Throughout the remainder of the North Pacific, mixing contributes less than 10% to the local change in heat storage. Advection, estimated from the local change in heat storage, the

contribution of mixing and the net surface heat exchange, is found to be of equal or greater importance than the net surface heat exchange in determining the local thermal structure.

An attempt is made to explain quantitatively the seasonal interactions existing between the changes in heat storage, the net surface heat exchange, horizontal mixing, and horizontal advection. A theoretical model of the time-dependent changes in heat storage in the 0 to 250 meter layer of the North Pacific is developed for this purpose, using the two-dimensional horizontal heat conservation equation. The equation is numerically solved by providing a horizontal mixing coefficient and developing a stream function to provide the required horizontal velocity field information. The numerical solution is iterated in daily steps through an annual cycle many times, varying the stream function or mixing coefficient each time, until the best agreement is obtained between the computed and the observed annual amplitudes and phases of heat storage. A circulation of 42 million $m^3\ sec^{-1}$ in the large subtropical anticyclonic gyre is required along with 32 million $m^3\ sec^{-1}$ in an East Pacific gyre. A mixing coefficient linearly increasing from $1 \times 10^6\ cm^2\ sec^{-1}$ at 8° North latitude to $11 \times 10^6\ cm^2\ sec^{-1}$ at 60° North latitude was found to be best. The success of the two-dimensional horizontal heat conservation equation in simulating the observed seasonal

changes in heat storage suggests that heat transfer by vertical advection and vertical mixing probably contribute little to the seasonal changes throughout most of the North Pacific Ocean. Using the final theoretical solution, an attempt is made to explain qualitatively the behavior of heat storage anomalies in the North Pacific Ocean. Hypothetical anomalies, simulating an abnormal net surface heat exchange, are added to the theoretical solution. The seasonal growth, movement, and decay of each anomaly is followed. The effect of increasing or decreasing the circulation is also tested. The results show that the heat storage in the area east of Japan and in the Western Tropical Pacific is primarily affected.