Abstract View

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Two-Dimensional Measurements of Ocean Microstructure: The Role of Double Diffusion

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ABSTRACT

Two-dimensional measurements of ocean microstructure are reported from four cruises to the Atlantic and Pacific. A Neil Brown Instrument Systems CTD has been modified to enhance its capability in the microstructure regime by replacing the standard thermistor with a Thermometrics FP07 “7-ms” thermisor, by separately digitizing the temperature channels at 50 Hz, and by using a unique passive-motion compensation device to obtain a uniform descent rate. The resulting instrumentation system measures the centimeter-scale temperature and conductivity signature of microstructure and the salinity structure over scales of a few tens of centimeters. Numerous observations of flat patches of microstructure of order several meters in the vertical and hundreds of meters in the herizontal are reported at sites of temperature-stabilized salinity inversions and salinity-stabilized temperature inversions, indicating active double-diffusive mixing. Finescale computation of the density ratio ($R_\rho = \alpha T_z/\beta S_z$) over vertical scales of 2 m reveals that much of the microstructure resides at sites with density ratio values in the supercritical salt-finger regime near $R_\rho \approx 1$. A temperature gradient zero-crossing detector has been used to quantify the results. Unconditional histograms of R_ρ and histograms conditioned on the presence of zero-crossings have been formed on the basis of 180 profiles for the four cruises (in the Sargasso Sea, near the Bahamas, and in the Pacific off San Diego). The measurements provide a significant data base for the double-diffusive regime of R_ρ, which is difficult to achieve in the laboratory ($R_\rho \approx 0.5$ to 3). In the salt-finger regime ($1 < R_\rho \lesssim 100$), the probability of observing microstructure increases rapidly as R_ρ, takes on values less than 4. In the diffusive regime ($0 < R_\rho$, < 1) the microstructure probability is low for R_ρ between 0 and 0.4 but increases for R_ρ values between 0.4 and 1. The microstructure patches with the greatest number of zero-crossings are shown to be at locations of more supercritical salt-finger values between R_ρ of 1.3 and 2. These findings show some of the strongest evidence to date for the predictions of Schmitt that the growth rate of salt fingers increases rapidly as R_ρ approaches 1 and that salt fingering must play an important role in oceanic mixing.

A two-dimensional observation of a microstructure patch that appears to be a Kelvin-Helmholz billow is shown. Several profiles follow the evolution of the gradient sharpening, the overturn, and a sequence of smaller overturns during collapse. Only one such event has been identified compared with the numerous patches of double-diffusive origin.

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