Temperature statistics above a deep-ocean sloping boundary: scale separation of internal waves and turbulence

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Abstract

A detailed analysis of the statistics of temperature in an oceanographic observational dataset is presented. The data is collected using a moored array of 144 thermistors, 100 m tall, deployed above the slopes of a seamount in the North Eastern Atlantic Ocean from April to August 2013. The thermistors are built in-house at the Royal NIOZ, and provide a precision better than 1 mK and very low noise levels. The thermistors measure temperature every second, synchronised throughout the moored array. The thermistor array ends 5 m above the bottom, and no bottom mixed layer is visible in the data, indicating that restratification is constantly occurring and that the mixed layer is either absent or very thin. Intense internal wave and turbulence activity is observed.

We compute the statistical moments (generalised structure functions) of order up to 10 of the distributions of temperature increments. The statistics are strongly modulated by the tidal phase (warming, cooling), and to a lesser extent by the height above the bottom. The results suggest that internal waves in this data set, while being strongly non-linear and continuously breaking, have quasi-Gaussian statistics. The generalised structure functions show a scaling behaviour for both ”small scale” (turbulent) and ”large scale” (internal wave) motions. The scaling exponent, however, is different. More interestingly, the transition between these two scaling regimes is abrupt for high order moments, i.e. a scaling break is present in the high order strutcture functions. We suggest that this abrupt break in the scaling behaviour is connected with the buoyancy length (velocity scale over buoyancy frequency). The fact that a sharp break is visible only in the high-order moments, at least in this data set, probably results from the fact that the buoyancy length is relevant only for turbulent motions. On the other hand, internal waves are scale-free, at least according to the dispersion relation from linear theory, and thus have scales both smaller and larger than the break. Since waves are less effective than turbulent motions at producing sharp gradients, their signature on higher order moments is smaller than for turbulent fluctuations, and thus smooth the transition between the two regimes only in the lower order moments. The possibility to define a (state-dependent) scale separation between waves and turbulence may have important practical applications, e.g._˜for LES modelling.

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