Temperature statistics above a deep-ocean sloping boundary: turbulence, intermittency and signs of convection.

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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, $100\,\mathrm{m}$ 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 $10^{-3}\,\mathrm{K}$ and very low noise levels. The thermistors measure temperature every second, synchronised throughout the moored array. The thermistor array ends $5\,\mathrm{m}$ 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 turbulence is observed, and a strong dependence of turbulence parameters on the phase of the semidiurnal tidal wave is also evident.

We compute the statistical moments (generalised structure functions) of order up to 12 of the distributions of temperature increments. The results are compared to those by Thorpe et al. [1] (skewness from an observational data set), Zhou and Xia [2] (skewness in laboratory thermal convection) and Warhaft [3] (passive scalars in grid generated turbulence). Strong intermittency is observed in particular during the downslope phase of the tide and in the upper half of the array, but a classical inertial range spectral slope is detected by the thermistors (figure 1b). Skewness of temperature increments suggests that convective structures are present in the upper half of the array during the upslope phase, and higher order moments also support this finding. On the other hand, in the lower half of the array during the same tidal phase, the statistics of temperature increments are compatible with those of a passive scalar in grid turbulence, as measured in laboratory experiments. We suggest that during the upslope phase convective plumes may be ejected from the bottom layer as suggested by numerical simulations [4, 5]. The downslope phase is sometimes thought to be more shear dominated [1], but our results suggest on the other hand that convective activity could still be playing a role at small scales.

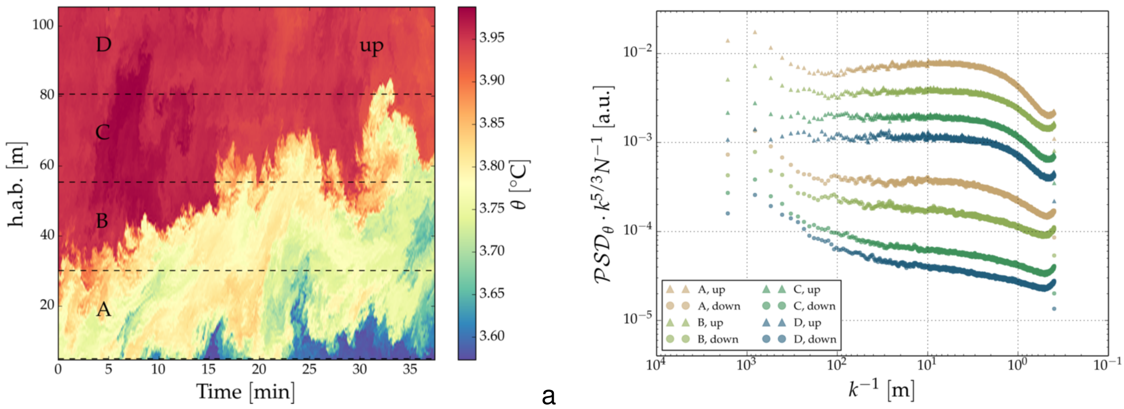

Fig. 1: A snapshot from the dataset, showing temperature throughout the sensor array during an upslope phase of the tide (a). Approximately 35 minutes of data are shown. Capital letters refer to the four segments into which the mooring is divided in the analyses. Compensated wavenumber spectra of temperature fluctuations, averaged during the two tidal phases (up for upslope, down for downslope) and in the four segments of the mooring (b). A vertical shift is applied to the spectra.

References

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