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A complete sketch for fine-structure contamination by internal waves

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Oceanic fine structure has been studied since the development of CTD and microstructure profilers allowed to resolve the vertical scales of temperature and salinity in the ocean. In the context of internal waves, it rapidly appeared that the advection of oceanic fine-structure may lead to erroneous interpretations of temperature measurements, and much theoretical work was achieved to distinguish real internal wave signal from the so-called fine-structure contamination. The pioneering work of Phillips (1971) revealed how the vertical advection of temperature steps by internal waves contaminates temperature records at fixed depths. Fine-structure contamination can be recognized in the super-buoyant part of the spectrum as a typical -2 slope, theoretically predicted for sharp stair cases in the temperature profile.

However, distinguishing fine-structure contamination from other (turbulent) signals in real datasets is sometimes difficult. We will show how the use of a large number of highly accurate temperature sensors allows to completely resolve the fine-structure contamination sketch. More precisely, the coherence spectrum between vertically separated sensors shows a characteristic π-phase signature above the Brunt-Väisälä frequency N that we can reproduce using a simple kinematic model.

The dataset used consists of temperature time series (1Hz during 1.5 year) obtained in the Canary Basin. Over a range of 132.5m, 54 NIOZ High Sampling Rate Thermistors (NIOZ-HST, 1mK relative accuracy) were moored around 1455m. Coherence between individual records shows a weak, but significant peak above N for all vertical separations. Instead of a dominant 0-phase difference over the range of sensors, as observed for internal waves at frequencies $f < \sigma < N$, f denoting the inertial frequency, this super-buoyancy coherence shows $\pi-$phase difference over a frequency band, that shifts to higher frequencies as the vertical separation between thermistors diminishes. In the time domain it is observed that this high frequency coherence mainly occurs when non-linearities in the temperature gradient, such as steps in the temperature profile, are advected passed the sensors. A kinematic model of fine structure contamination successfully reproduces these observation.

Surprisingly, the canonical -2 slope of the temperature spectrum above N is not observed in the in situ data, which rather slope like -8/3. The -8/3 slope can nevertheless be reproduced in our kinematic model, in which there is no turbulence, provided the jumps in the temperature profile are not infinitely thin.