Anatomy of Turbulence in Thermally Stratified Lakes[1]

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Abstract

Turbulence within the thermocline of two thermally stratified lakes, Lake Biwa and Lake Kinneret, was investigated using a Portable Flux Profiler (PFP). This instrument provided high resolution profiles of temperature, conductivity and two components of velocity within a measuring volume of approximately 8 mm^3. Each data profile was segmented into statistically stationary segments. A range of properties of the turbulence, including direct estimates of the vertical mass flux, were then calculated for each segment.

It was found that turbulence in the thermocline was generally patchy, but within a patch dissipation levels were relatively high. The turbulent motions were found to be fine-grained with small Thorpe scales and a large skewness of the distribution of the displacement scale. This is distinct to that found in the ocean, where shear instability produces large overturns.

The measurement showed that the net vertical mass flux in the thermocline was negligible and less than that predicted by Osborn (1980). This is explained by noting that the net buoyancy flux consisted of two opposing parts: a downgradient irreversible flux due to turbulent mixing and an upgradient reversible flux due to restratification that often cancel each other within a segment. The low measured net buoyancy flux within the interior of the lakes suggested that other processes, such as gravitational adjustments and benthic boundary layer processes, should be responsible for the basin-averaged vertical transport in these lakes.

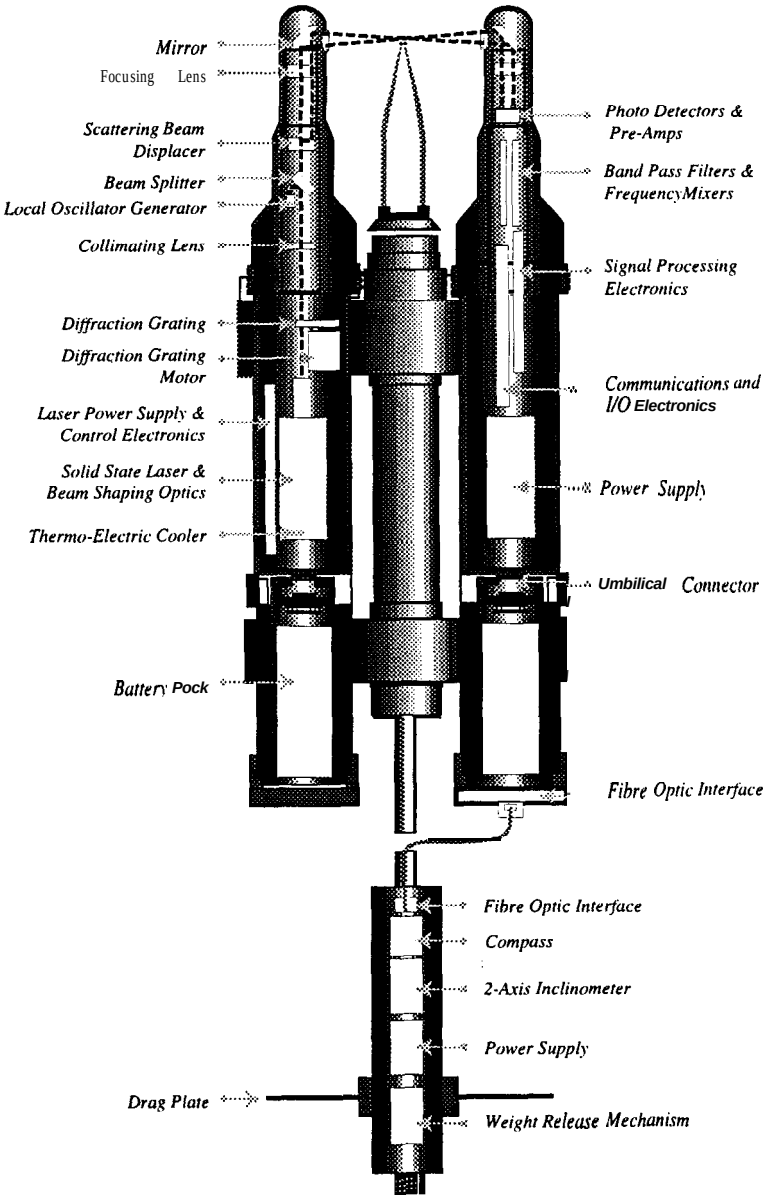

Figure 3: Schematic of The PFP (Portable Flux Profiler) showing the different parts of the instrument. The length of probe is 1.5 m and its weight is about 25 kg in the air.

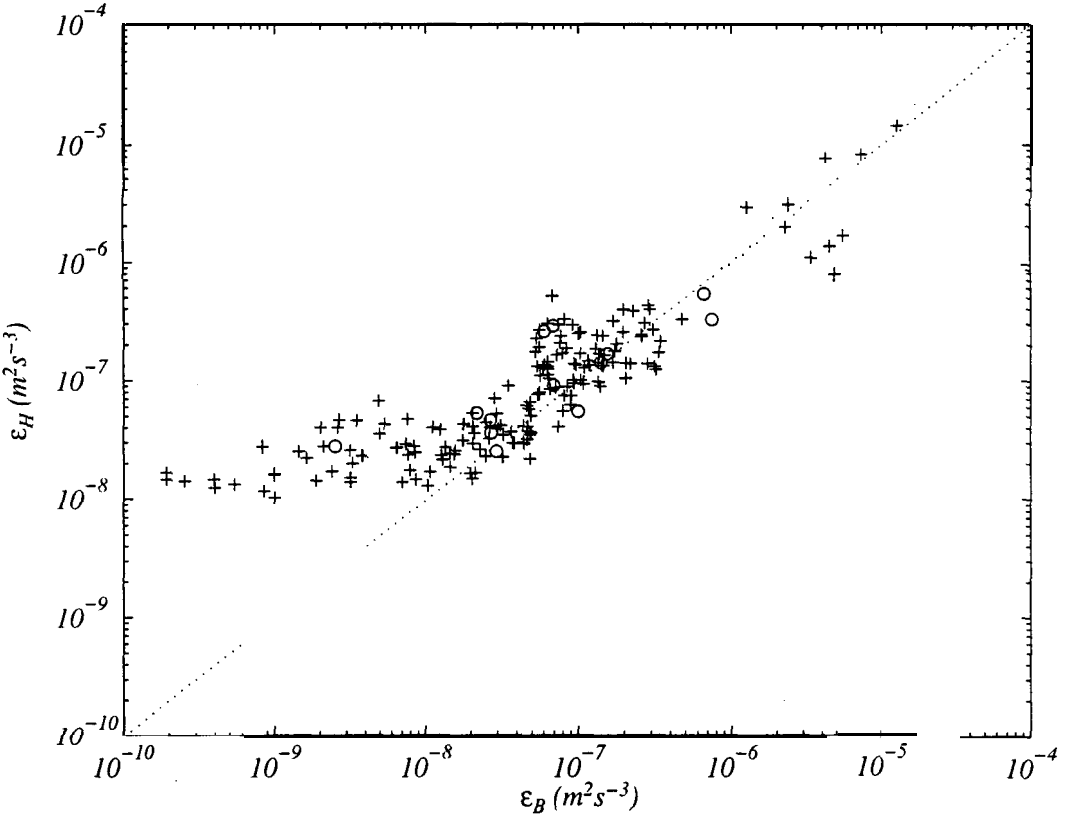

Figure 9: Dissipation obtained from vertical shear of horizontal velocity, ϵ_H (6), plotted verses the simultaneously obtained value from vertical gradient of temperature, ϵ_B, showing correlation between direct and indirect methods when $\epsilon_B > 10^{-8}$ m^2s^{-3}. Dotted line is $\epsilon_H = \epsilon_B$. Data points are classified according to the skewness of their centred displacement scale, ***Sk.*** Open circles (o): ***Sk*** $\leq$ 1.5 and pluses (+): ***Sk*** > 1.5.