MIXING AT THE CONTINENTAL SLOPE IN THE FAEROE-SHETLAND CHANNEL

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In shallow, flat-bottom seas like the North Sea sediment transport is mainly induced by turbulent friction due to wind and tide. When water depths exceed 100 m, these processes cannot directly affect such transport, because their bottom friction is too weak. Indirectly however, they can still dominate sediment resuspension in such seas, provided they interact with the stable density stratification above a sloping bottom, for example by generating waves in the interior. Using novel high-resolution measurements it is shown that either process may dominate resuspension in a confined basin like the Faeroe-Shetland Channel. Near-bottom steep waves carrying over 100 times more sediment than background values either have tidal or four-days (storm passage) periodicity in areas less than 100 km apart.

Solibores

During a previous experiment in the ~1000 m deep Faeroe-Shetland Channel (FSC), carried out in 1999, it was observed that approximately half-way the continental slope near-bottom temperatures could drop dramatically more than 5°C within a few minutes (Fig. 1 red curve). Such a temperature drop did occur only 3 times in a 12-days period at the particular site halfway FSC. This periodicity seemed to concur with passages of atmospheric disturbances. Normally, the turbulent mixing associated with storms does not reach deeper into the ocean than the upper 100 m from the surface. The connection between the passage of storms and temperature variations much deeper down (500 m or more) is through the deflection of isopycnals (lines of constant density) on a sloping bottom. A sudden release of near-bottom fronts, ‘solibores’, moving up the slope passes moored instruments very quickly within a few minutes, whilst whirling up sediment, typically 50 m above the bottom, due to the vigorous vertical currents exceeding 0.1 m s^{-1} associated with the front. However, the dominant four-day periodicity remained a puzzle, since the dominant periodicity in observed (internal wave) currents was tidal.

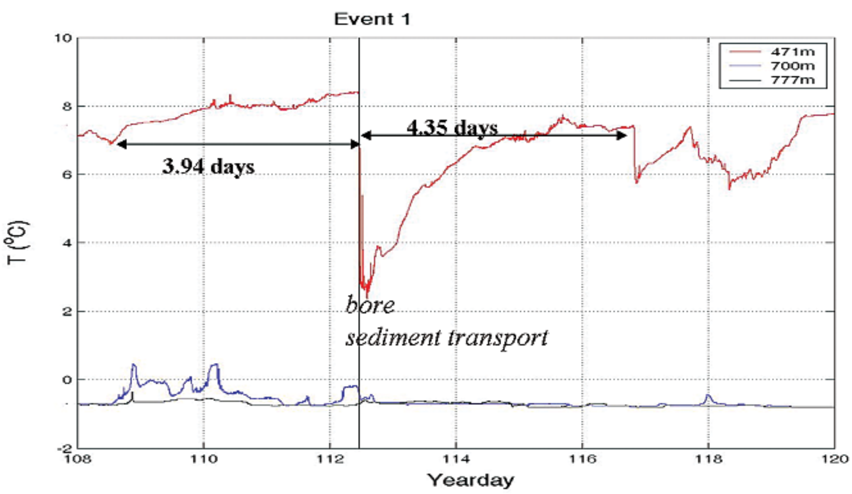

Fig. 1. Twelve days of near-bottom (8 m above the bottom) temperature time series obtained during PROCS, april 1999 (see Fig. 2). Moorings were at 471 m water depth (red), 700 m (blue) and 777 m (black).

New experiment

Therefore, a new experiment, carried out in 2005, aimed specifically to study possible tidal non-linear near-bottom wave motions. It

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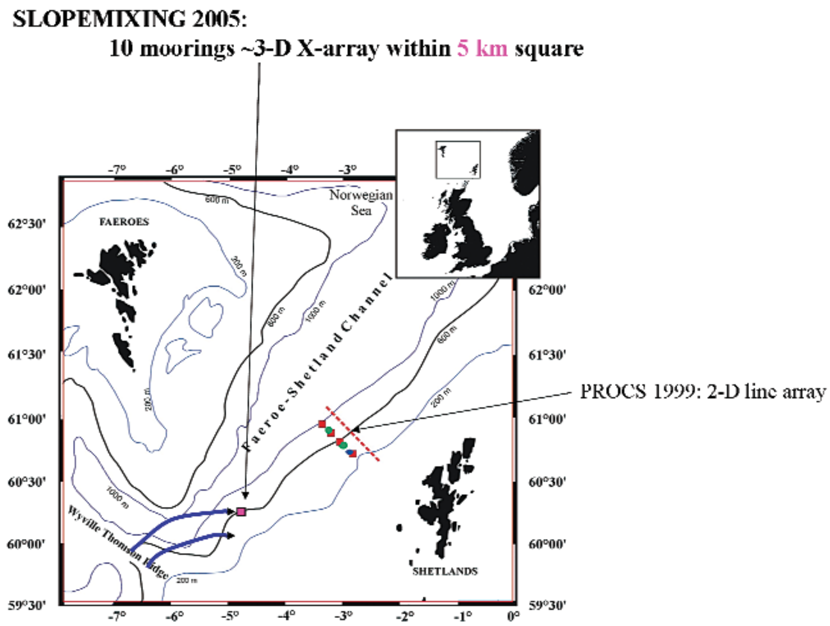

Fig. 2. Faeroe-Shetland Channel with mooring locations of projects PROCS (2-D array) and SLOPEMIXING (3-D site). The latter is closer to the Whyville-Thomson Ridge, the presumed major source of internal tidal waves, which may refract along the blue arrows.

followed a hypothesis that the dominant internal tide source in the FSC is at the Whyville-Thomson ridge at its southern entrance and that waves emanating from the ridge refract soon after generation (Fig. 2). The new experiment was set-up nearly 100 km from the previous one, and with close mooring spacing (2.5 km horizontally) at and around the 600 m isobath.

The newly observed periodicity in near-bottom temperatures (Fig. 3) is dramatically different from the previous one, whereas the range of temperature variations is about similar (compare with Fig. 1). At the 2005-site temperature variations are highly tidal periodic. Closer inspection shows that the largest temperature variations do not occur during springtide, but during neaps around day 254 (compare upper panel of Fig. 3 with surface pressure dominated by spring-neap cycle in lower panel). Equally surprising is the fact that the three different moorings, located close together, show large differences in occurrence and timing of the passage of sudden temperature variations. Apparently, their horizontal length scale and amplitude are highly variable. Nevertheless, these short-scale phenomena do dominate sediment resuspension like in the 1999-data, as may be inferred from the large vertical current and 25 dB (factor ~300) increase in turbulent acoustic reflection more than 60 m above the bottom, as measured in unprecedented detail using a fast-sampling ADCP (acoustic Doppler current profiler) (Fig. 4). Apparently, the periodicity of generating mechanism (tide or atmospheric disturbance, or a combination of both) is irrelevant for the sediment resuspension due to the vigorous turbulence moving up the slope.

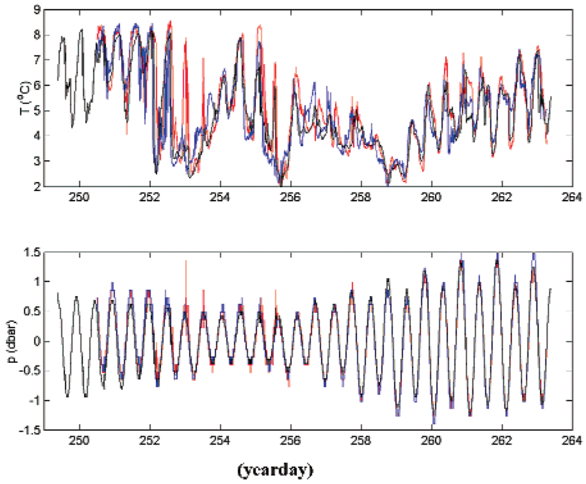

Fig. 3. Upper panel as Fig. 1 but for 14-days of data obtained during SLOPEMIXING, September 2005. Three moorings were located 2.5 km apart horizontally, all at the 600 m isobath. Lower panel shows corresponding pressure data.

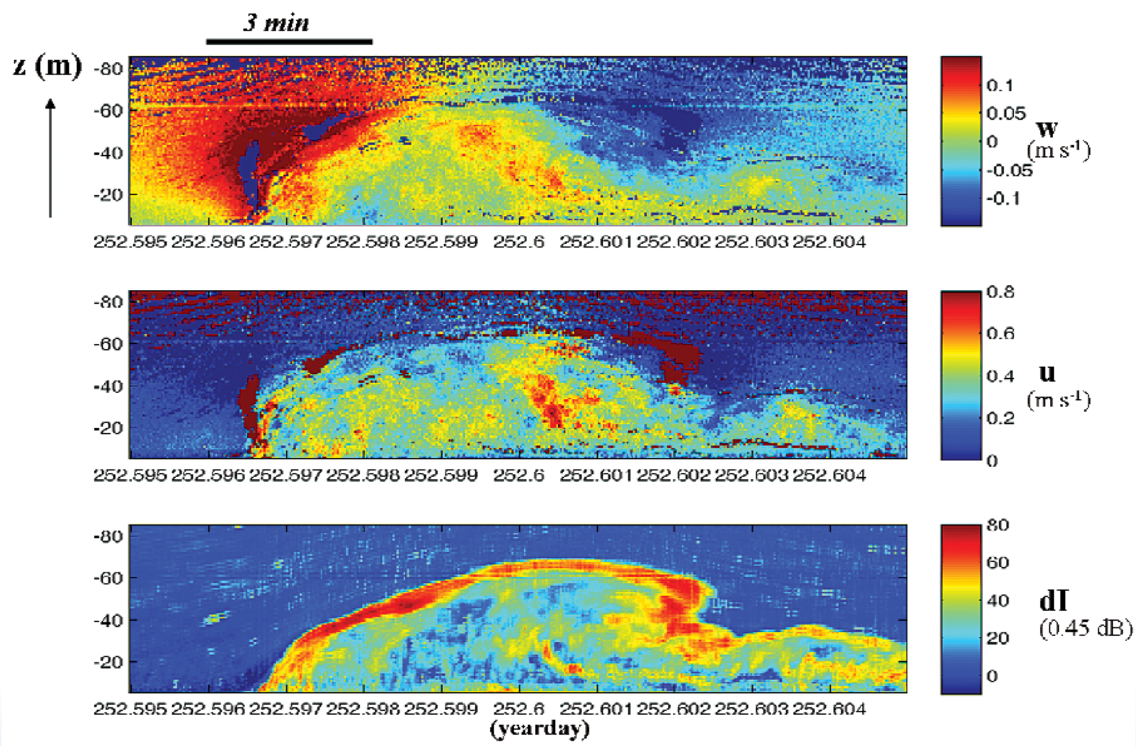

Fig. 4. Detailed [14 minutes] example of solibore passage as observed during SLOPEMIXING 2005 using 2 Hz sampling ADCP. Time (in yeardays) – height above the bottom (in m) panels show: Vertical currents (w; upper panel), which are very large upward near the front of the solibore, which propagates from left-to-right up the slope. Upslope current (u; middle panel). Acoustic amplitude relative to time mean ('relative echo intensity' dI; lowest panel), a measure for suspended sediment and stratified turbulence, is found largest along the upper rim of the solibore and in small patches in its interior. The dark blue stripes and patches in the upper panel and the same in brown in the middle panel represent bad data.