How well do Autonomous Gliders Capture the Internal Tide?

Mark Inall[1], Marie Porter[1], Estelle Dumont[1], Dmitry Aleynik[1], Toby Sherwin[1] and David Smeed[2]

[1]*Scottish Association for Marine Science, Scottish Marine Institute, Oban, Argyll PA37 1QA, email: mark.inall@sams.ac.uk*

[2]*National Oceanography Centre, Southampton, SO14 3ZH*

1. Introduction

Internal waves are a major source of energy available to mix the stratified oceans. Tidal and near inertial internal waves form the most energetic part of the spectrum and the non-linear cascade of energy from the low frequency, long wavelength part of the spectrum fuels irreversible mixing at smaller scales. Vertical mixing mediated by internal tides (ITs) is an important part of the deep ocean buoyancy budget (1, 2), as well as ocean margin buoyancy and nutrient budgets (3, 4). The continental shelf break acts as a large-scale internal-wave generator and is responsible for a significant transfer of energy from barotropic to baroclinic tidal waves (5-7) which is important for the biogeochemical systems at the shelf break (8). Internal tides (IT), although a ubiquitous feature of the west-European shelf edge in summer, exhibit significant regional variability with the on-shelf energy fluxes ranging from a maximum value of about 1000 W m^{-1} in the Celtic Sea (9) to about 100 W m^{-1} on the Malin Shelf (10). There is also a significant amount of energy in IT-produced non-linear, solitary-like, internal waves (*11*, *12*). Here we report on recent Glider-based measurements from the Celtic Sea margin (Figure 1) made between June 2012 and January 2013, along a transect which crosses the continental shelf edge.

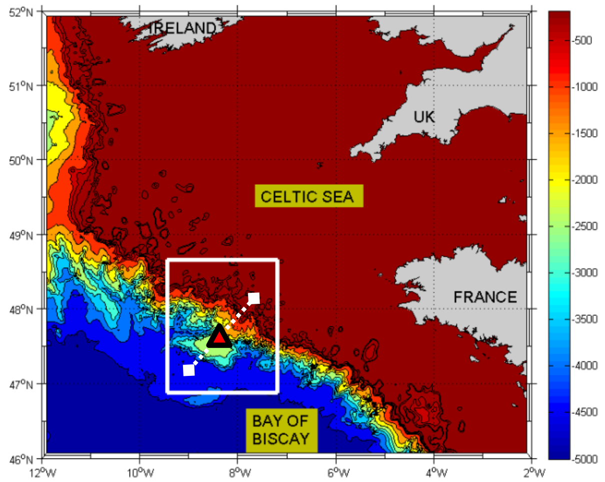

Figure 1. Celtic Sea shelf edge bathymetry (ETOPO1.1). Contours are at 500m intervals from 5000m to 500m, then at 50m intervals to 200m. The shallowest contour delineates the shelf break at 180m. The Glider and mooring study area is shown by a white rectangle, and the nominal position of the Glider transect with a white dotted line. Current meter mooring at station LT1 in 1500m water depth is indicated by a red triangle.

2. Observations and Instrumentation

Four Gliders in total where used in this study (Figures 2a and b), of both the Slocum ('Coprolite', 'Bellamite' and 'unit_194') and Seaglider designs ('Talisker'): of the four, three where depth-rated to 1000m and one depth-rated to 200m ('unit_194'). The Gliders typically move with horizontal and vertical speeds through the water of 0.25 ms^{-1} and 0.15 ms^{-1}, respectively. Their capacity to effectively sample the internal tide is therefore not obvious, because of the similarly between IT phase speeds and induced water velocities and the through-water speeds of the observing platform. Between them, the four Gliders continuously occupied the study area for seven and a half months (Figures 2a and b); a region where the depth integrated linear IT generating potential (*13*) has maxima centred over both the shelf break, and over a deeper steep section centred on the 3000m isobath (Figure 2c). The Glider occupations spanned the period of the seasonal breakdown in stratification (Figure 3), during which time the depth of the well-mixed surface layer descends from summer-time values of approximately 50m, to 250m and deeper, well below the depth of the shelf break.

Initial analyses of the glider data show an intriguing signal of the deep and shallow structure of the internal tide (Figure 4). In the winter, when the mixed layer has descended below the shelf break, large amplitude semi-diurnal fluctuations in the depth of the 250m and 800m isopycnals are seen. Doppler smearing of the spatial structure of the IT is clearly an issue, and reference to the current meter data at LT1 is needed to correct for this bias.

It is anticipated that the most constructive analyses will come from comparison between these data and virtual glider trajectories through the high-resolution MITgcm model being presented by Vlasenko (*14*).

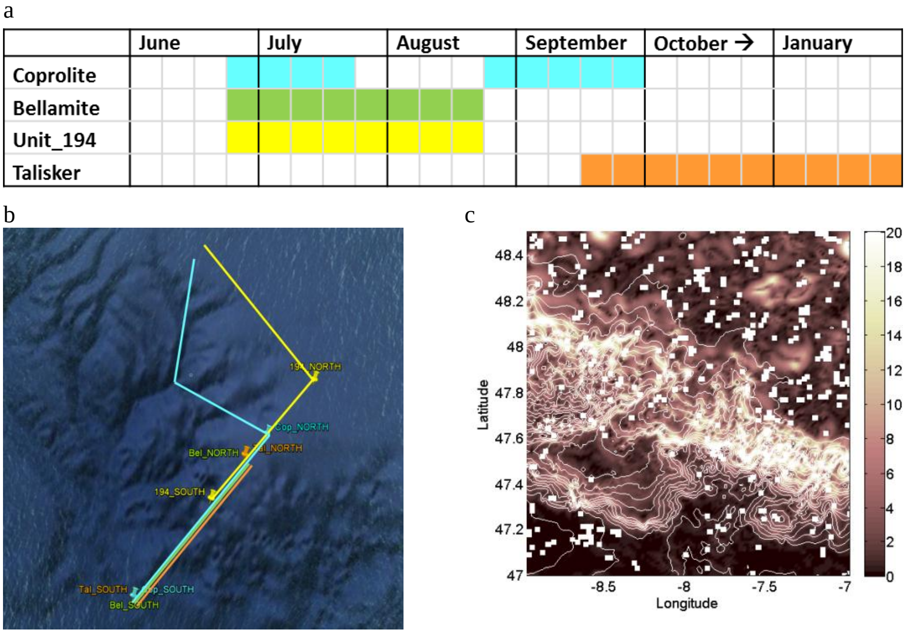

Figure 2. (a) Time-line of Glider deployments, first column gives the Glider name, colours correspond to nominal transect paths, shown in (b). (c) Vertically integrated internal tide forcing potential, after Baines (*13*). Scale is arbitrary, stratification used corresponds to the summer situation (June 2012), and the tidal forcing used comes from the current meter mooring at station LT1 (1500m water depth).

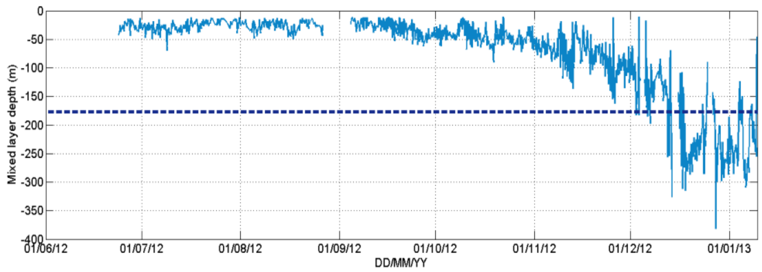

Figure 3. (a) Time series of the depth of the well-mixed surface layer from the Glider data: defined here as the depth at which the temperature first deviates by >0.2°C from the temperature at 10 m.

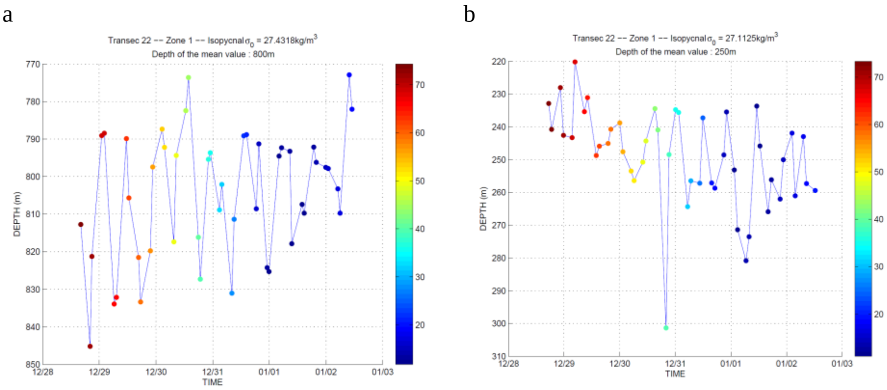

Figure 4. Depth of two selected iospycnal surfaces on transect No. 22 (January 2013). (a) isopycnal 27.432, average depth = 800m and (b) isopycnal 27.113, average depth = 250m. Dots indicate individual consecutive glider dives, and the colour indicates distance (in km) along the transect, where the zero reference point is at the seaward end of the transect.

3. References

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