Geophysical Research Abstracts
Vol. 15, EGU2013-7583, 2013
EGU General Assembly 2013

Stochastic Heterogeneity Mapping as a tool to quantify turbulence in reflectivity layers of thermohaline staircases in the Tyrrhenian Sea

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Processed multi-channel seismic data acquired in the Tyrrhenian Sea in April-May 2010 with the B/O Sarmiento de Gamboa provide images of oceanic thermohaline staircases. Thermohaline staircases are regular, well-defined step-like variations in vertical profiles of temperature and salinity. In the ocean they are thought to be the result of double diffusion driven by the two order of magnitude difference in the diffusivities of heat and salt. Staircases are believed to have an anomalously weak internal wave-induced turbulence, making them suitable for the estimation of a lower limit of turbulent disturbances detectable by multi-channel seismics.

We apply stochastic heterogeneity mapping based on the band-limited von Kármán function to post-stack time-migrated seismic data to extract stochastic parameters such as the Hurst number (a measure of reflection interface roughness) and correlation length (scale length). For scale sizes smaller than the correlation length, the von Kármán model describes a power law (fractal) process where the Hurst number is its exponent.

We present the results of our analysis corroborated by benchmark tests performed on synthetic seismic data generated from random fractal surfaces. The synthetic tests are found to verify the robustness of the technique. Lower Hurst numbers represent a richer range of high wavenumbers and therefore correspond to a broader range of heterogeneity in reflection events. We interpret a broader range of heterogeneity as indicative of a greater degree of turbulence. Some areas of the seismic data show a spatial variation in Hurst number across several frequency bands that may indicate some preferential coupling of energy at different depths.