

1. Introduction

- Ocean generated microseisms (OGM) are faint ground oscillations generated by ocean wave activity. Useful for passive seismic imaging and ocean monitoring/climate studies.
- Ireland has highly energetic wave climate and is close to major OGM source region.
- Two generation methods:
 - Single frequency microseisms (SFM): limited to shallow water regions, occur at ocean wave frequency [Hasselmann, 1963].
 - Double frequency microseisms (DFM): no depth dependence, occur at twice the ocean wave frequency [Longuet-Higgins, 1950].
- Understanding the source distribution and generation mechanisms for OGM will help interpretation of imaging and monitoring studies.
- 2 arrays were deployed in Ireland to study the wavefield composition and source distribution in the North-East Atlantic near Ireland .
 - UDA : Deployed March 2012 – present.
 - UCA: Deployed February – May 2012.
 - Data from a third array (EKA) was provided by AWE Blacknest.
- OBS network was deployed Jan 2016 – Sept 2016 to study effect of continental shelf on propagation of OGM..

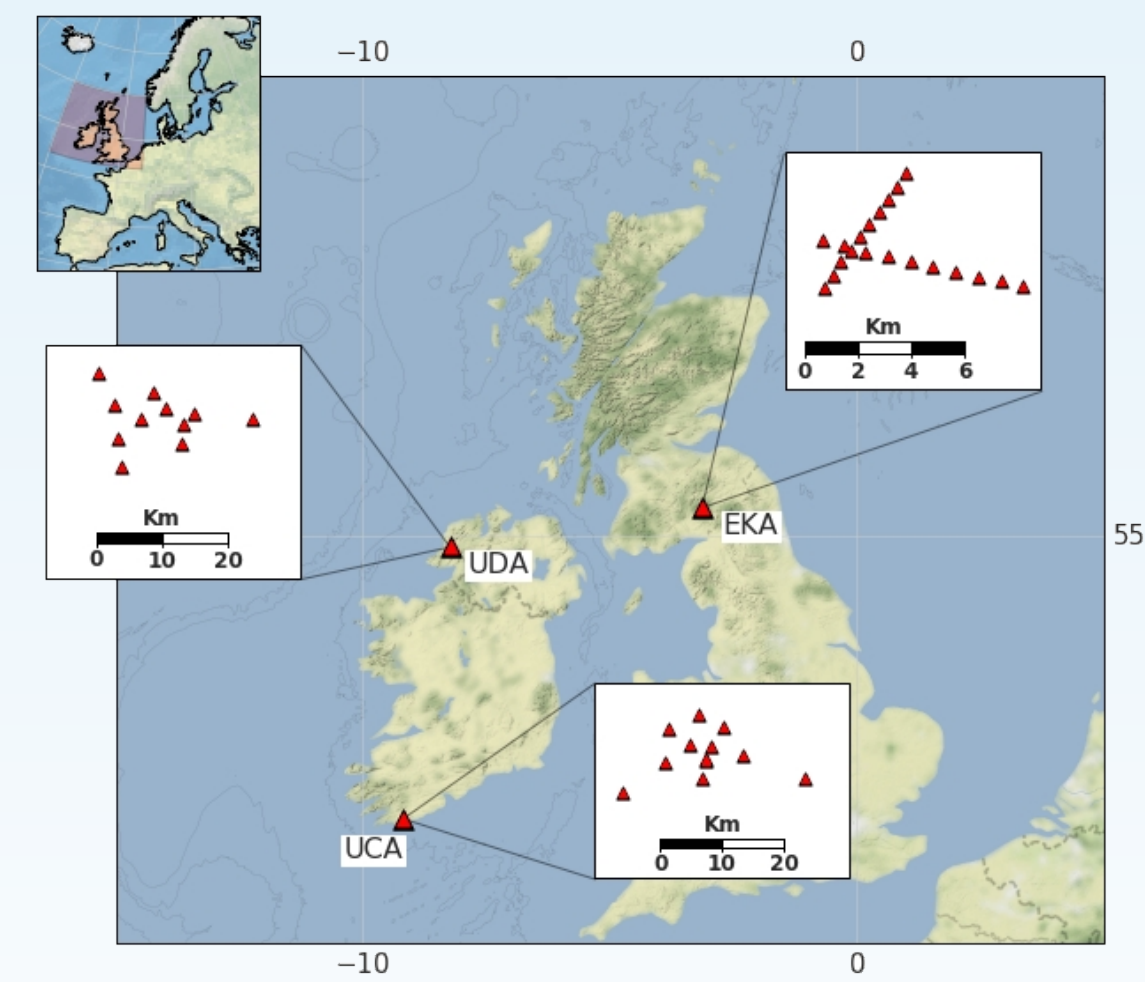
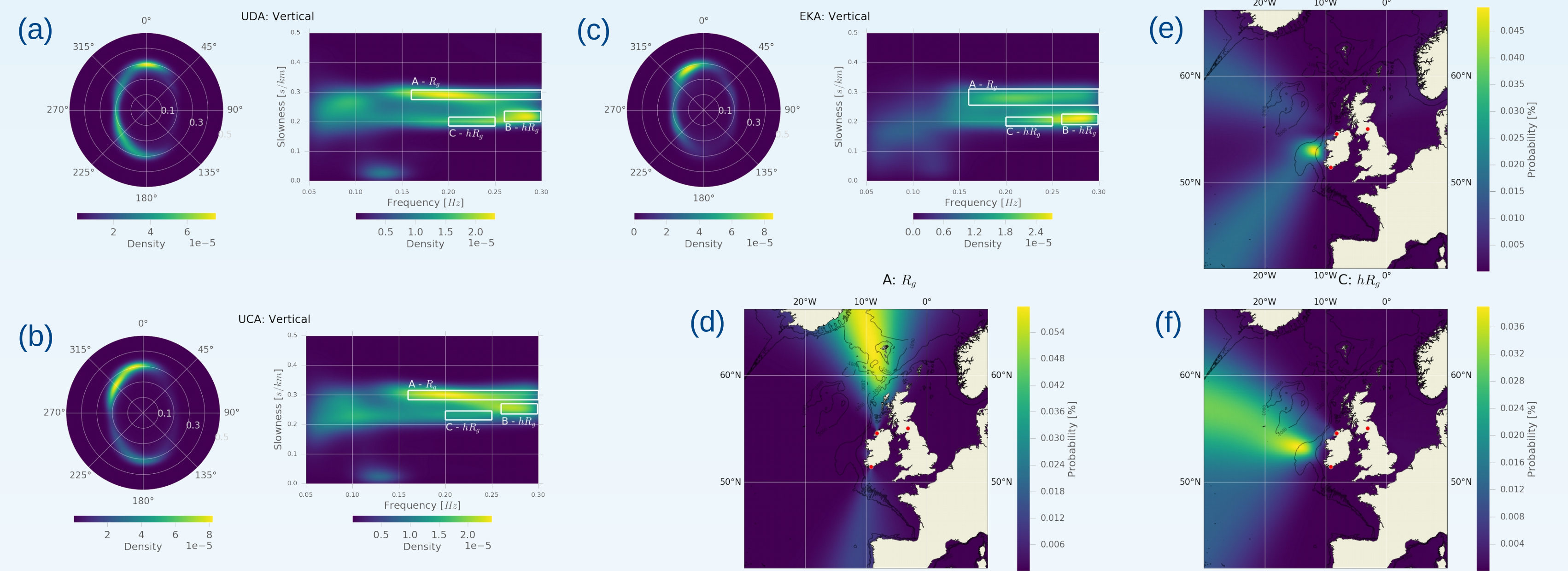


Figure 1: Location and geometry of the two arrays in Ireland. UDA and UCA consist of 11 3-c broadband seismometers. EKA consists of 20 Guralp vertical component broadband seismometers.

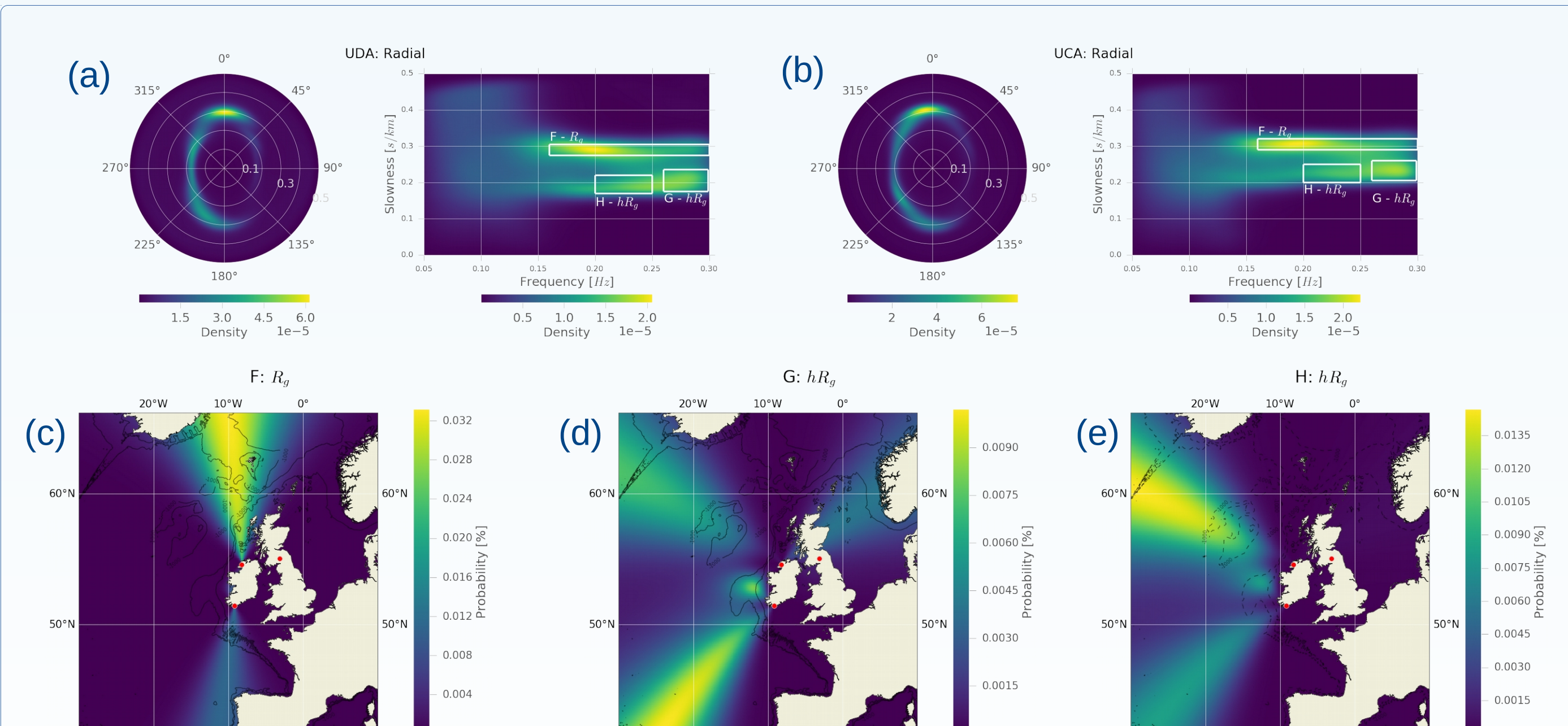
2. 3-Component Array Analysis

- Figures 2, 3 and 4 show the results of 3-component capon f-k analysis [Capon 1969; Gal 2014] for UDA and UCA, for the month of April 2012. Figure 2 also shows the EKA data.
- The microseism wavefield is complex, largely consisting of surface waves, both Rayleigh (R_g : figures 2 and 3) and and Love (L_g : figure 4). Fundamental (R_g and L_g) and higher modes (hR_g and hL_g) are present. At times body waves can also be observed (not shown).
- Different locations are observed for R_g and L_g sources.
- Similarly different locations are observed for R_g and higher mode R_g sources.
- DFM sources appear in continental shelf region with the exception of hR_g which may contain some signal related to more distant sources.



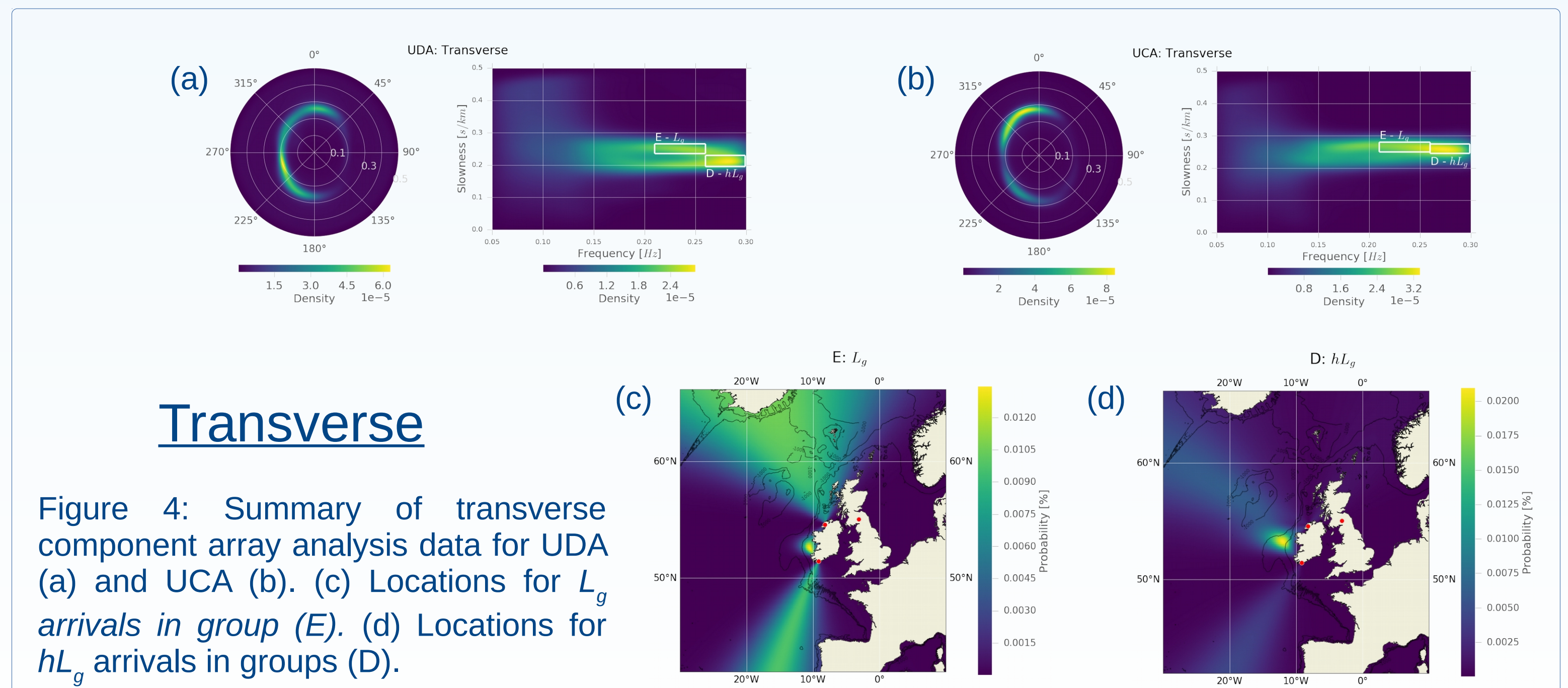
Vertical

Figure 2: Summary of vertical component array analysis data for (a) UDA, (b) UCA and (c) EKA. (d) Locations for R_g arrivals in groups (A). (e) Locations for hR_g arrivals in groups (B). This may contain some L_g arrivals (compare to (D) figure 3.). (f) Locations for hR_g arrivals in groups (C).



Radial

Figure 3: Summary of radial component array analysis data for UDA (a) and UCA (b). (c) locations for R_g arrivals in group (F). (d) locations for hR_g arrivals in groups (G). (e) Locations for hR_g arrivals in groups (H).



Transverse

Figure 4: Summary of transverse component array analysis data for UDA (a) and UCA (b). (c) Locations for L_g arrivals in group (E). (d) Locations for hL_g arrivals in groups (D).

3. OBS Network

- 10 Guralp CMG 40T 50Hz – 60s seismometers with HighTech HTI-01/04-PCA/ULF 100s – 8kHz hydrophones.
- Deployment 01/16 – 08/16.
- ORK05–ORK10 depth 2-3 km.
- ORK01–ORK04 depth < 120m.

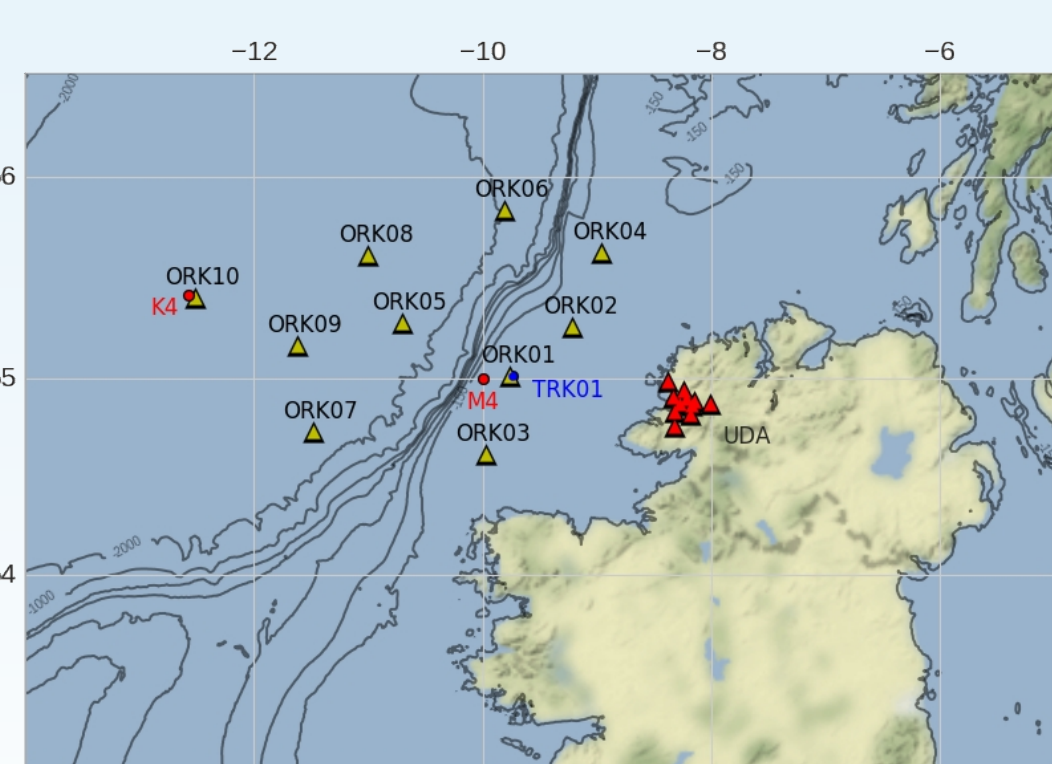


Figure 5: Map of OBS network, also showing the array in Donegal.

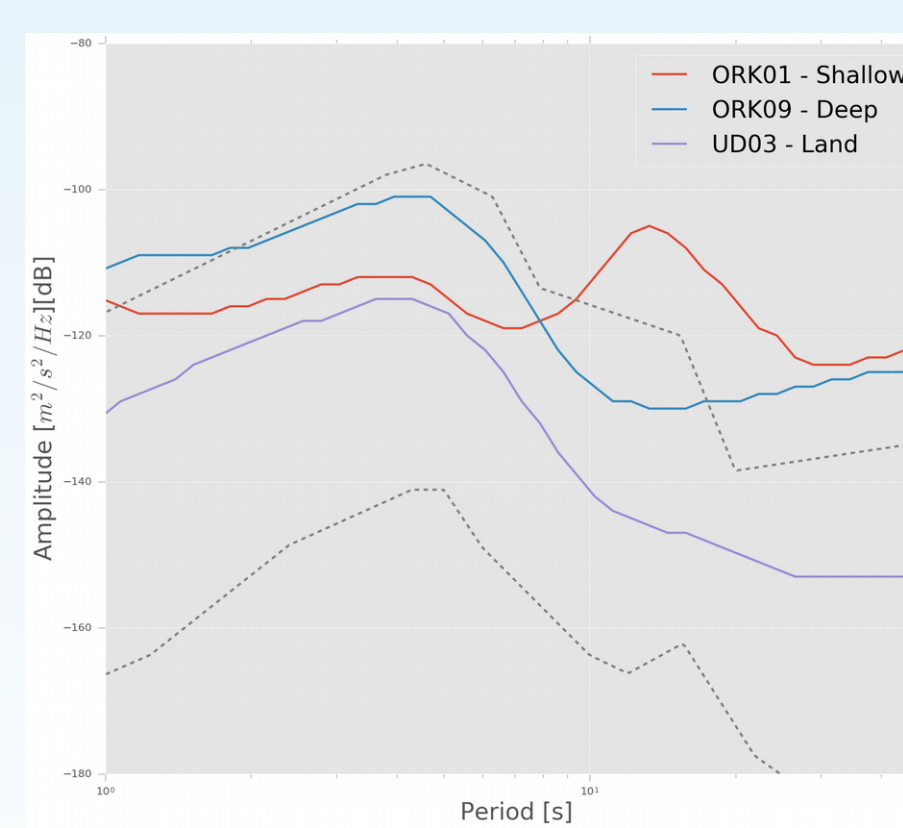


Figure 6: Power spectra for ORK01 (red), ORK09 (blue) and UD03 (purple).

- Note the large amplitude SFM amplitudes in shallow water – probably due to non-propagating modes (short wavelength OGM) that do not propagate onshore.
- Also note the large amplitude DFM in deep water (not observed by array).

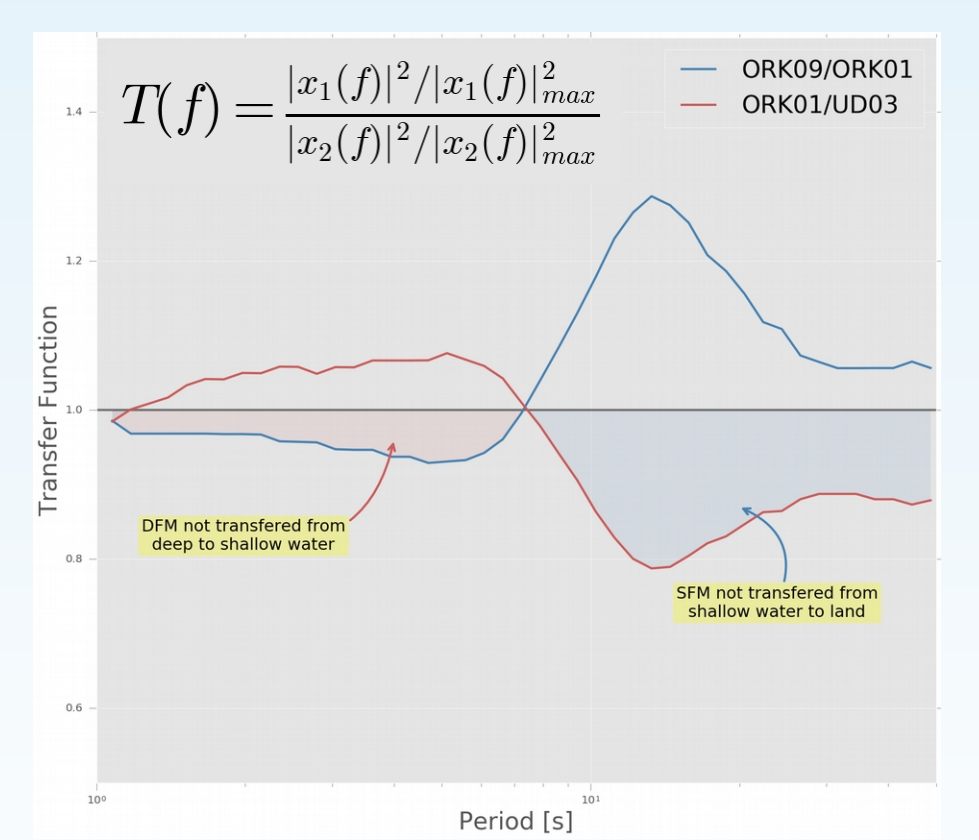


Figure 7: Transfer functions from deep to shallow water (blue) and shallow to land (red).

4. Synthetic Tests

- To model microseism propagation it is necessary to consider the ocean-acoustic and seismic wave-fields.
- Propagation from a source approximately 500 km off-shore was considered.

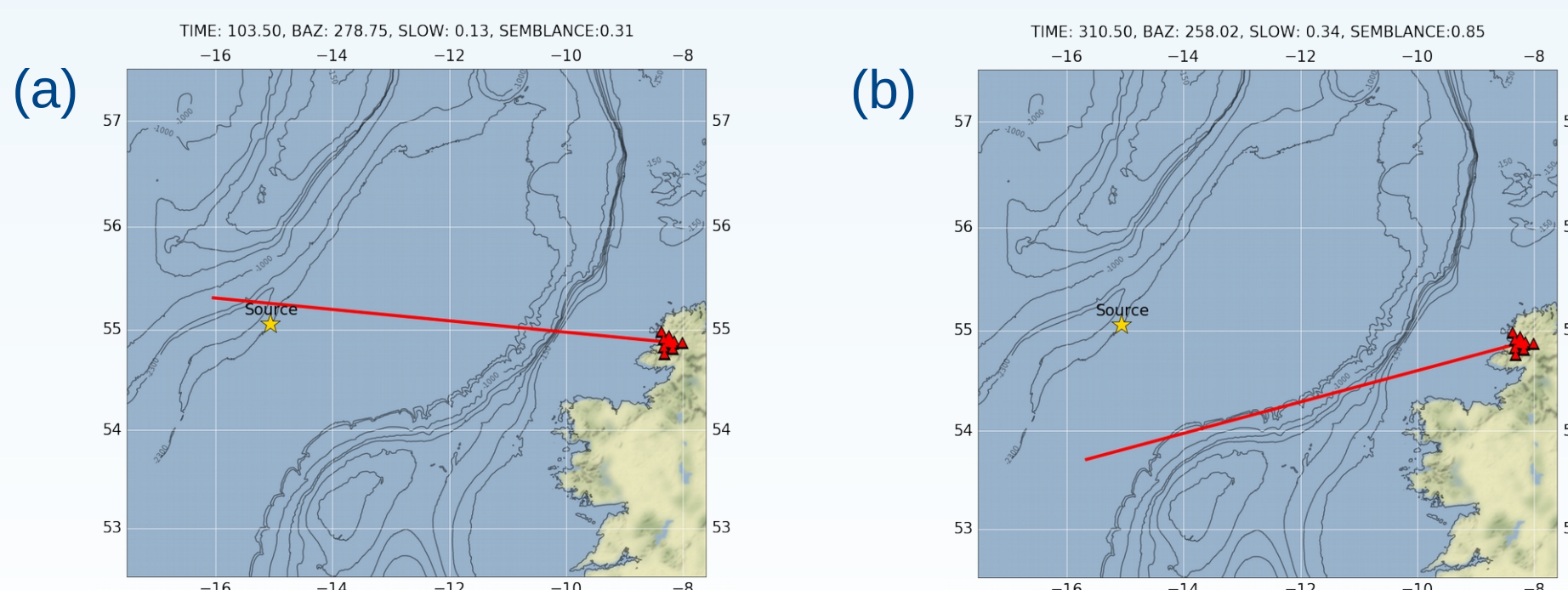


Figure 6 (a): Back-azimuth for body wave arrivals (red line) at 135 s. (b) Back-azimuth for body wave arrivals (red line) at 313.5 s

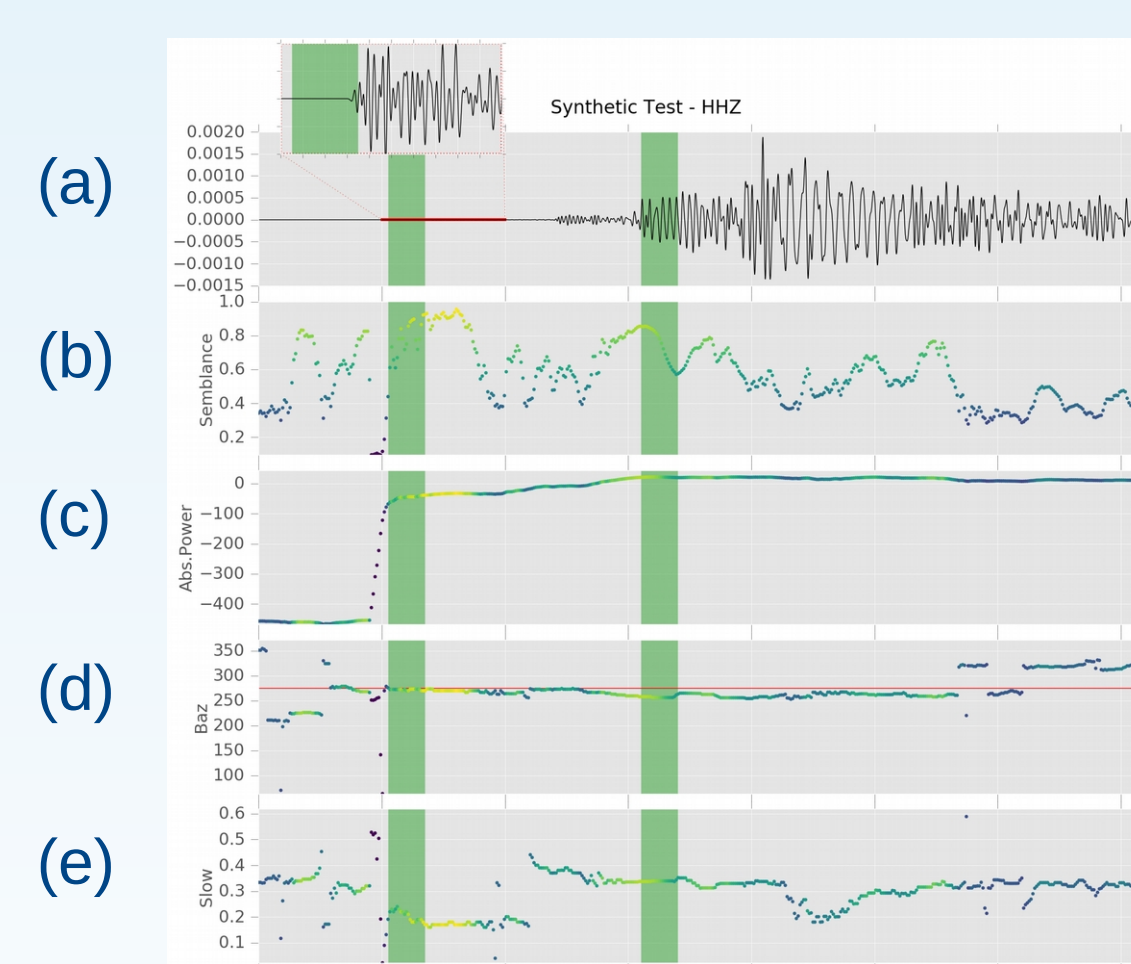


Figure 5: (a) Synthetic vertical ground displacement. (b-e) Output from array processing of synthetic array data. Vertical green lines represent the two time windows shown in figures 6 (a) and (b).

- The early body wave arrivals point close to the source, however, later arriving surface waves point further to the south.

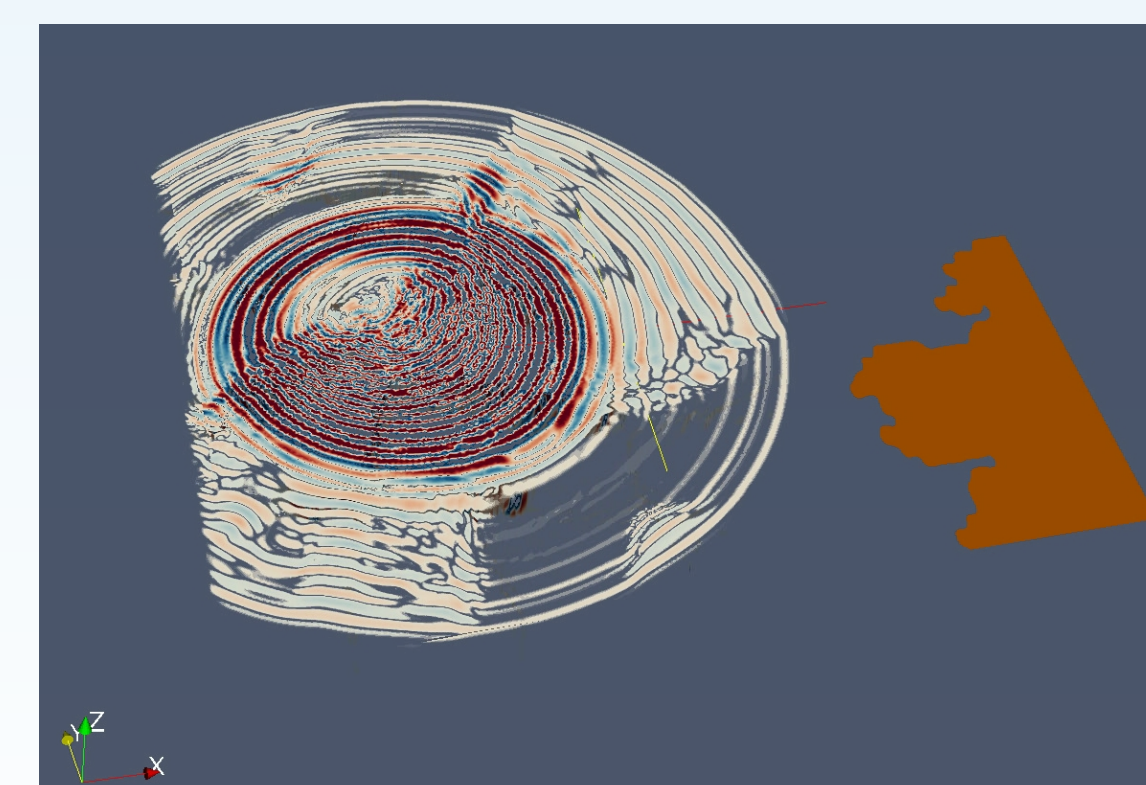


Figure 7: (a) SPECIFEM3D data showing influence of the shelf edge on OGM propagation.

5. Conclusions

- Microseism wavefield observed from Ireland primarily consists of R_g and L_g waves with both fundamental and higher modes present.
- Seismic arrays show DFM source locations near shelf edge.
- OBS show larger amplitude DFM in deeper water regions.
- Can be explained by propagation effects at shelf edge.