Differentiating ocean induced seismic surface waves generated offshore Ireland

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Summary

3D simulations of acoustic/elastic waves have been performed in order to improve our understanding of the wavefield associated with seismic ambient noise induced by ocean waves activity. To do so, our 3D synthetic model comprises a broad area of the Irish offshore including key features such as the Rockall Trough and the Porcupine basin. The model is defined by the water layer as well as sediments, crust and mantle layers and can therefore be used for several acoustic/seismic applications. To better characterize changes in the seismic wavefield generated from different "ocean noise" source locations, multiple areas of the model are investigated separately. The simulated wavefield recorded on synthetic seismograms enables us to look at the effect of the water column, sediments thickness but also steep gradient changes in bathymetry and sediments. Whereas Rayleigh waves are broadly observed in the simulations, Love waves become only significant for specific source locations. Understanding the radial and transverse seismic wavefield is important as both Rayleigh and Love waves will exhibit different sensitivity to the underlying velocity structures.
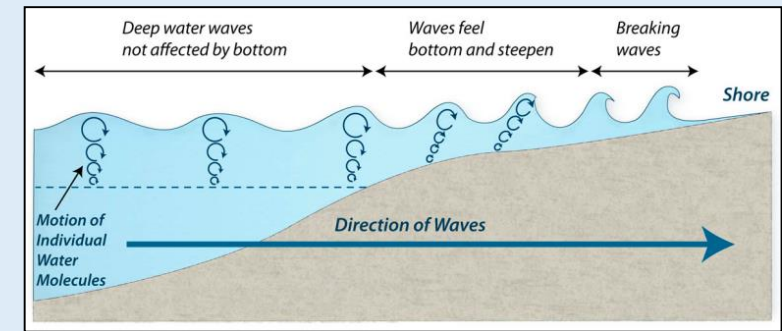
Background

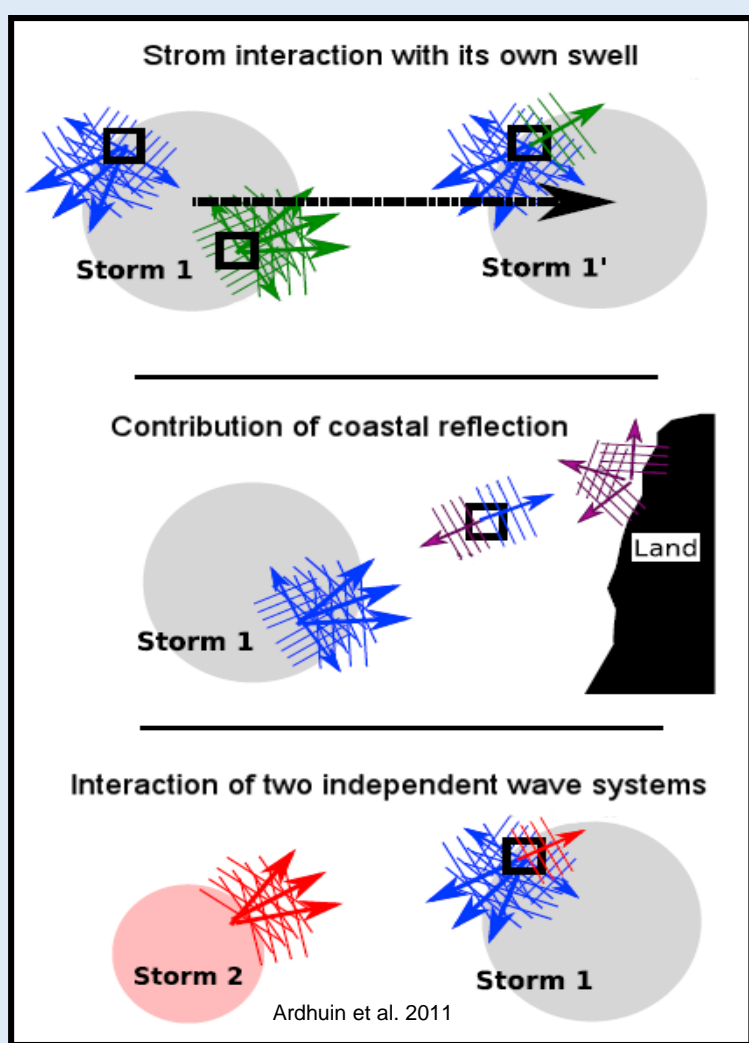Ocean wave pressure fluctuations (acoustic) on the sea floor which generate low frequency seismic waves

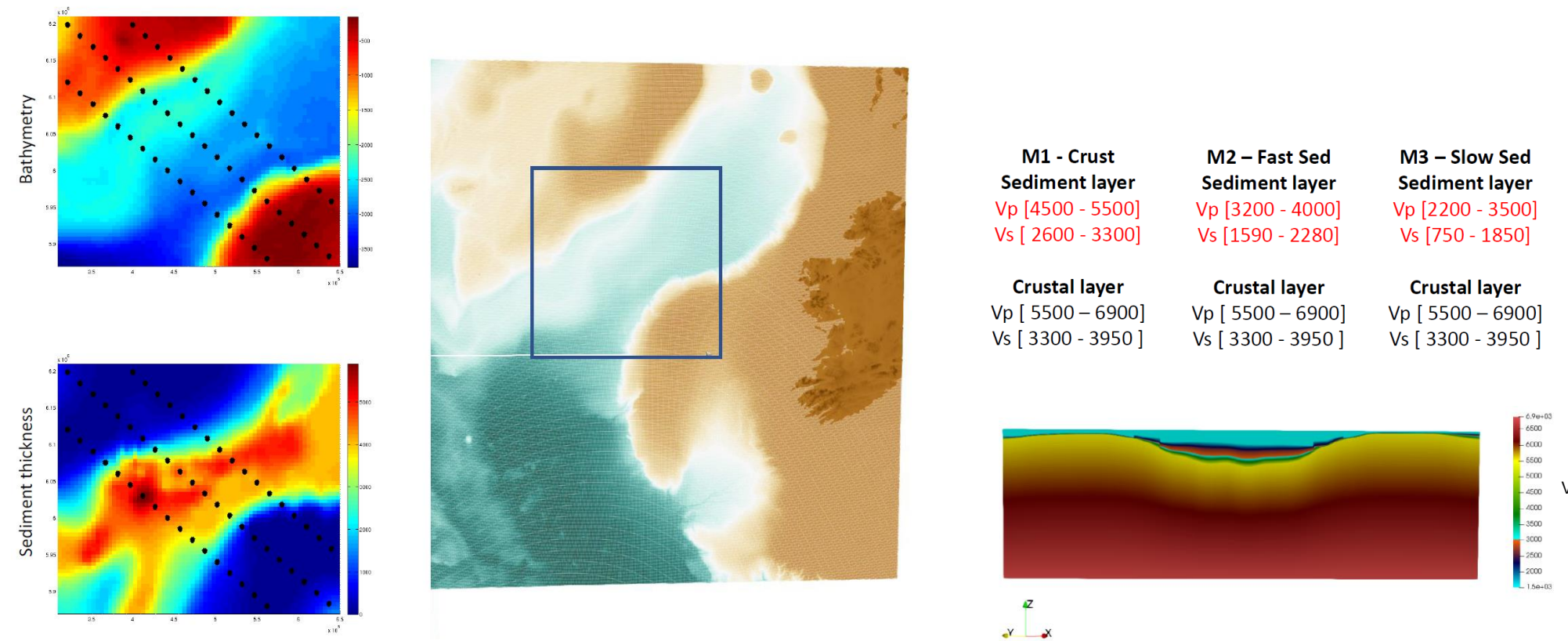Secondary Microseisms (**SM**)
- Recorded signal = 1/2 period of ocean waves
- Water depth independent

Strom interaction with its own swell

Storm 1   Storm 1'

Contribution of coastal reflection

Storm 1   Land

Interaction of two independent wave systems

Storm 2   Storm 1

Arthun et al. 2011

Primary Microseisms (**PM**)
- Recorded signal = same period as ocean waves
- Max depth = half a wave length

Deep-water waves not affected by bottom   Waves felt bottom and steepen   Breaking waves   Shore

Motion of individual Water Molecules   Direction of Waves

Local 3D modelling :

Velocity effects

Bathymetry

Sediment thickness

M1 – Crust Sediment layer	M2 – Fast Sed Sediment layer	M3 – Slow Sed Sediment layer
Vp [4500 - 5500]	Vp [3200 - 4000]	Vp [2200 - 3500]
Vs [2600 - 3300]	Vs [1590 - 2280]	Vs [750 - 1850]
Crustal layer	Crustal layer	Crustal layer
Vp [5500 – 6900]	Vp [5500 – 6900]	Vp [5500 – 6900]
Vs [3300 - 3950]	Vs [3300 - 3950]	Vs [3300 - 3950]

Vp

Location effects

Transverse Comp. 4km depth   Radial Comp. 4km depth

Transverse Comp. 4km depth   Radial Comp. 4km depth

Sediment basement Gradient

M1

M2

M3

Regional Synthetic Model of the Irish Offshore

Bathymetry

Sediments Basement

In the 3D model, three different mediums are included: water (acoustic), sediments (elastic) and crust (elastic). In addition to the bathymetry, the significant thickness of the low-velocity sediments of the Rockall Trough need be to taken into account for the study of seismic wave propagation in the region of interest.
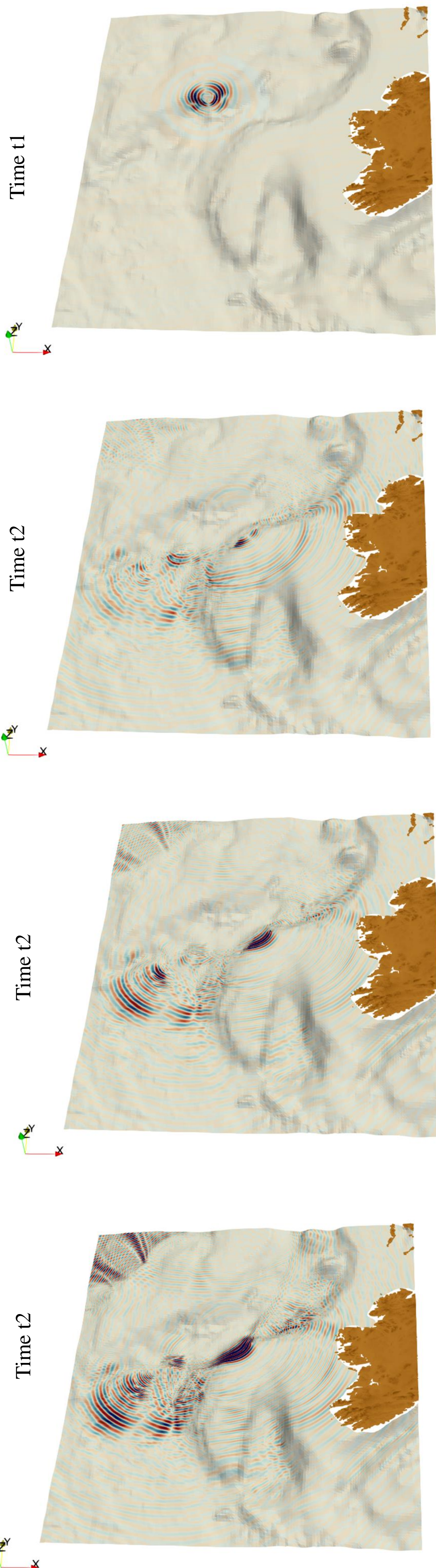
1,800,000 mesh elements
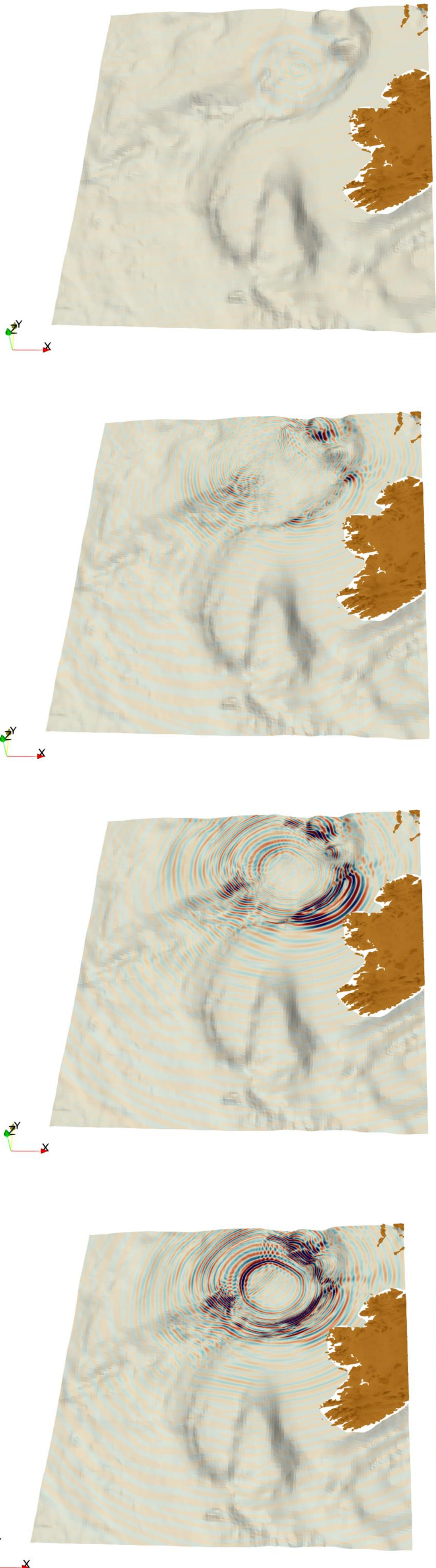vertical acoustic sources = Ricker wavelet 0.15Hz

0 km

60 km

Vertically stretch by factor 5

VP
1.5e+03   3000   4000   5000   6000   7000   8.2e+03

SPECFEM3D
The code simulates acoustic (fluid), elastic (solid), coupled acoustic/elastic, poroelastic or seismic wave propagation.

In the simulations presented here, the effects of sediments basement are highlighted for transverse, radial and vertical components of the seismic wavefield for 3 different source locations.

Source 1   Source 2   Source 3

Time t1

Time t2

Time t2

Time t2