Investigation of Apparent Seismic Velocity Changes Related to Microseism Noise Source Distribution

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1. Project Aims

- Using background seismic noise to measure velocity changes.
- Distinguish between apparent velocity changes caused by noise source variablity and real velocity changes caused by stress changes.
- Estimation of the impact of the noise source distribution on the recovered Green's function.

2. Measuring Velocity Changes

- Secondary microseism noise is generated by the interaction of standing ocean waves with the seafloor.
- Correlations of ambient noise are typically used for Green's function retrieval between a pair of stations.
- Green's functions are often used to monitor variations in seismic wave velocity.

3. Ireland - Test Area

- Good location to study apparent velocity changes
  - Tectonically quiet.
  - Close to dominant noise sources in the North East Atlantic.

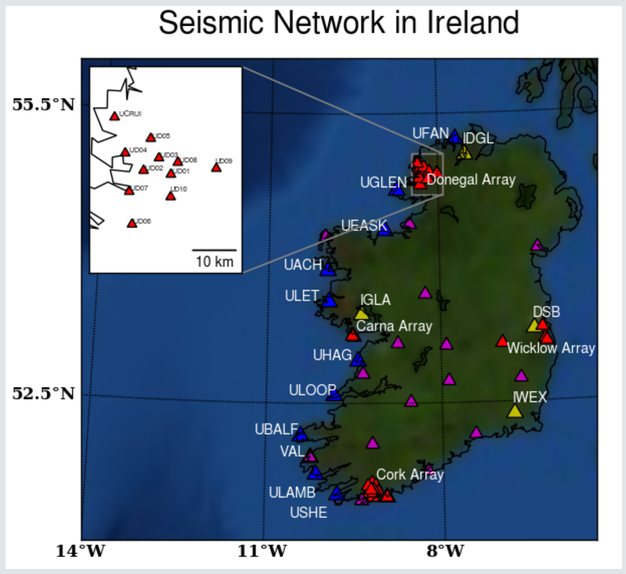

Figure 1: *Seismic network deployed in Ireland; the blue and red stations are operated by UCD. The pink stations are deployed by the Dublin Institute for Advanced Studies (DIAS).*

4. Ireland - Source distribution

- Theoretically background noise sources for imagery should be uniformly distributed in space but this rarely occurs in nature (Fig.2).

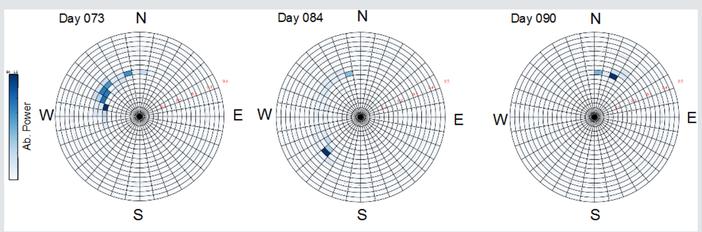

Figure 2: *Changes in temporal distribution of sources using fk analysis of unseperated data for 3 different days (period of 24 hours). The data is recorded at the Northern array (Fig.1) and it is filtered between 4 and 8 seconds.(courtesy of David Craig).*

5. Synthetic test

- Synthetic data can be used to constrain the performance of the analysis technique.
- The amount of apparent velocity changes can be assessed.

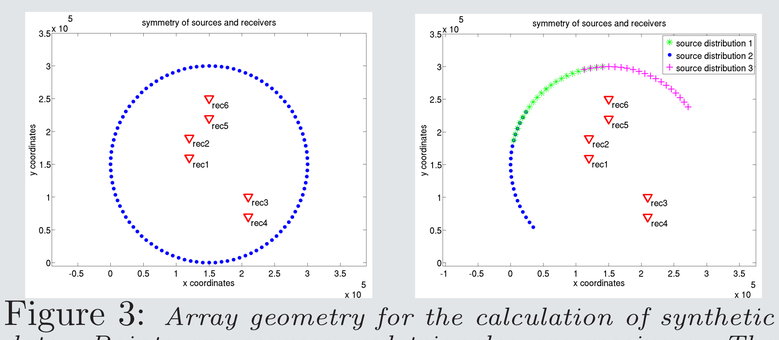

Figure 3: *Array geometry for the calculation of synthetic data. Points are sources, red triangles are receivers. The non-uniform distributions are calculated according to the results in Fig. 2.*

- Synthetic seismic data are calculated in an unbounded infinite, homogeneous medium (S wave velocity of 3333 $\frac{m}{s}$).
- Source time function is a Ricker wavelet (convolved with white noise) with vertical forcing, the z-component of the data is used for the following calculations (Fig.4).

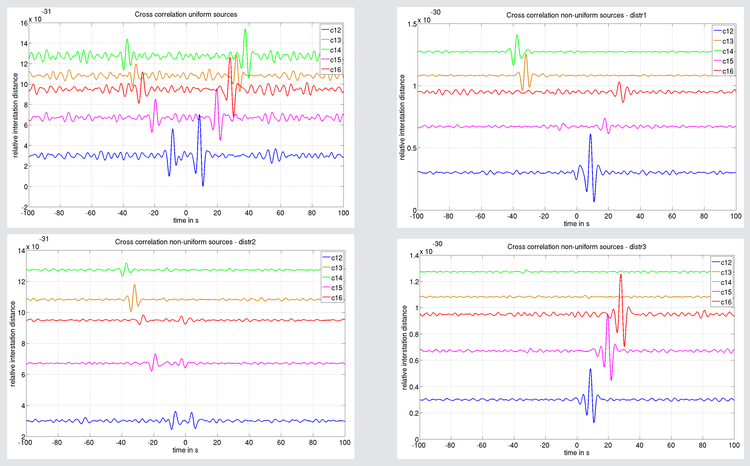

Figure 4: *Cross correlations of rec 1 with each other receiver plotted over relative receiver distance for all 4 source distributions(Fig.3).*

uniform	distr 1	distr 2	distr 3
3333 $\frac{m}{s}$	3590 $\frac{m}{s}$	3120 $\frac{m}{s}$	3324 $\frac{m}{s}$

Table 1: *Apparent velocity calculated from the lag times of the cross correlations in Fig. 4.*

- The non-uniformity of sources may lead to apparent changes in Green's functions (Fig. 4). This could lead to a misinterpretation of temporal changes in seismic wave velocity.

8. Future Work

- The apparent velocity changes will be investigated using field data from Ireland for known temporal changes in noise source locations.
- The convergence of the Green's function over time will be assessed.
- The method will be applied to Pico del Teide volcano in Tenerife where we expect rapid velocity changes and the stress sensitivity will be determined.

9. Acknowledgements

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Figure 2 is produced by David Craig.

6. Ireland - Cross correlations

- The cross-correlations are computed with data from the Donegal Array (Fig.1).
- The data is corrected for the instrument response.

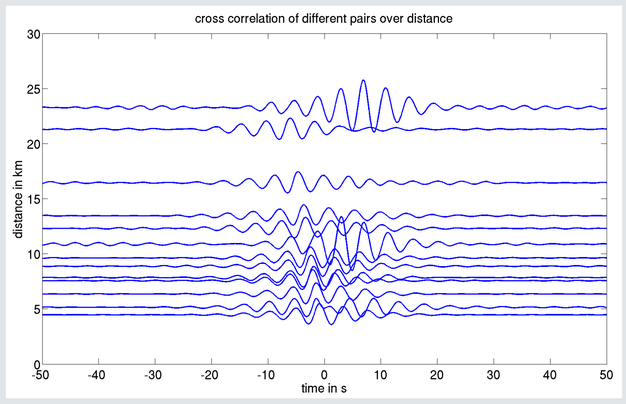

Figure 5: *Cross correlation of different pairs of stations of the Donegal array (Fig.1) plotted over interstation distance.*

- To visually improve Figure 5 the cross-correlations are replotted in separate plots with respect to the direction of the interstation line of the pairs.

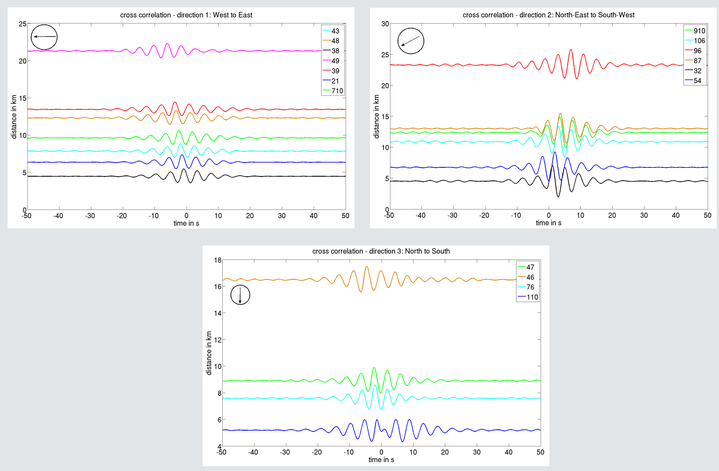

Figure 6: *Cross correlations of different pairs of the Donegal array (Fig.1) sorted by the orientation of the interstation distance plotted over interstation distance for three different directions.*

- The analysis of the cross-correlations sorted by 3 different directions lead to an estimated source area in the West of the Donegal Array.

7. Conclusion

- Initial synthetic tests show the distribution of noise sources is very important.
- The wavefield is well recovered for uniformly distributed noise sources.
- Asymmetrical distributions do not allow us to properly reconstruct the seismic wave velocity.
- Ideally the source receiver offset is parallel to the line connecting the two receivers (Fig.4).
- The source distribution affects the amplitude and the first arrival time of the recovered Green's function. If array data is used these changes can be used to estimate a source area.
- The velocity is correctly calculated if the source area is located on an extension of the line connecting two receivers.
- The non-uniformity of the noise sources can be seen in the real data.

10. References

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