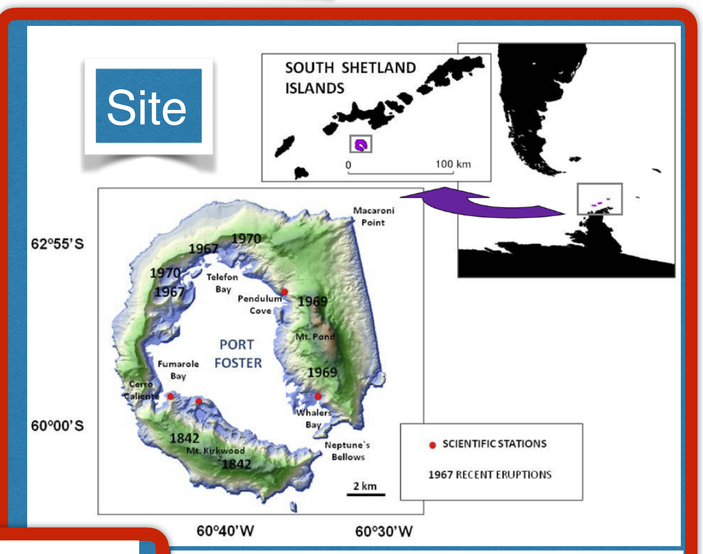
Imaging Earth Heterogeneity using Scattered Waves

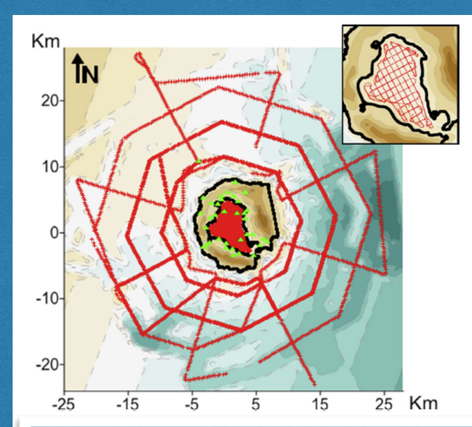
Edoardo Del Pezzo[1,2], Jesus Ibanez[2], Janire Prudencio[2,3], Francesca Bianco[1]

1 - I.N.G.V - Osservatorio Vesuviano (Italy)
2 - Istituto Andaluz de Geofisica. Universidad de Granada (Spain)
3 - Department of Computer Science.Georgia State University, Atlanta (USA).

We present a new method to achieve separate images in scattering and intrinsic attenuation, based on Energy Transport Model applied to coda waves.
We separately estimate Qi and Qs for single paths from coda analysis and use new kernels based on numerical simulations to achieve 2D images of Deception Island Volcano in Antarctica.
The images are compared with images for the same area obtained using the same data with different and simpler weighting functions.

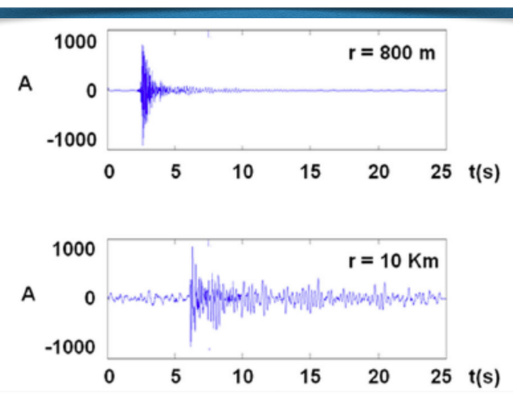


Geographic location of South Shetland Islands and map of Deception Island. Recent eruption are indicated (Year of occurrence).

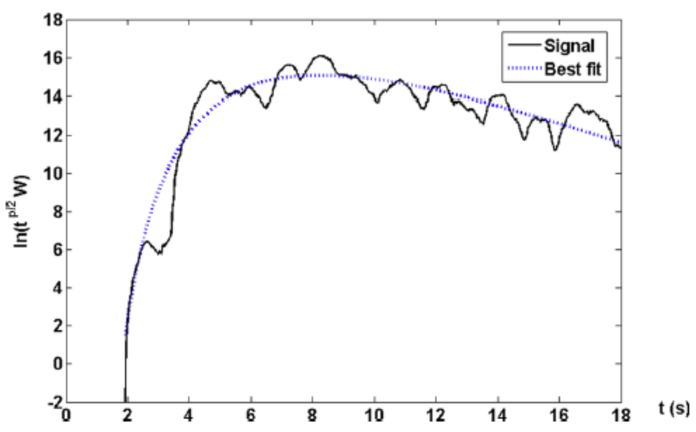


The red dots represent the air gun shot positions. Green triangles are receivers. Zoom inside Deception bay shows the high density of shots

Data and seismic attributes



The same shot recorded at 800 m and at 10000 m distance.



Energy envelope (black curve) with its best fitting theoretical model. Single path Qi and Qs parameters are the parameters of the best fit curve

Model

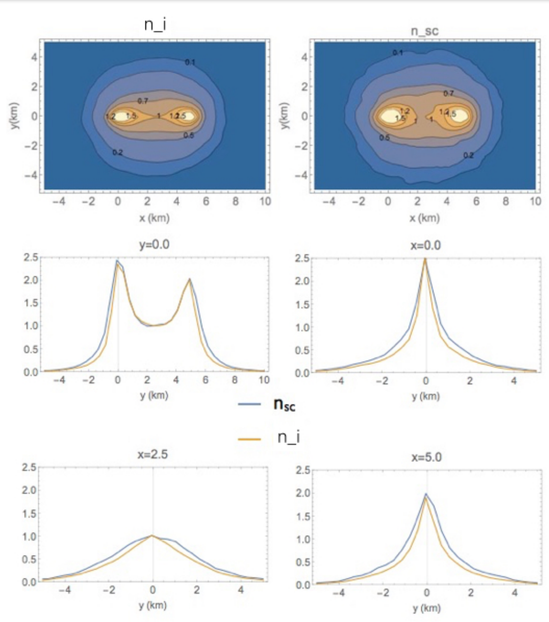
$$E^{2D}[r,t] = \frac{W_0 exp[-Le^{-1}vt]}{2\pi rv}\delta[t-\frac{r}{v}] +$$

$$+ W_0 H[t-\frac{r}{v}] \cdot \frac{B_0 Le^{-1}}{2\pi vt}(1-\frac{r^2}{v^2t^2})^{-1/2} \cdot$$

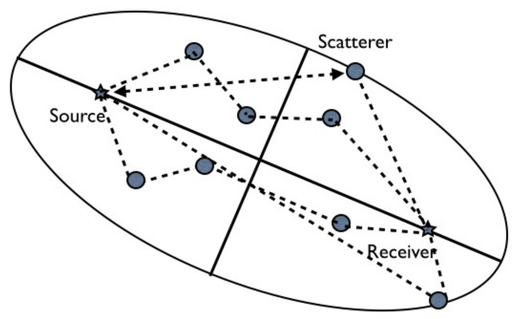
$$\cdot exp[B_0 Le^{-1}\sqrt{v^2t^2-r^2}]exp[-Le^{-1}vt]$$

$$B_0 = Q_T/Q_S \qquad Le^{-1} = \frac{2\pi f}{v}\left(\frac{1}{Q_S}+\frac{1}{Q_i}\right)$$

f is the frequency
v is the wave speed
r is the source-receiver distance
t is the "lapse time"
B_0 and Le are Albedo and Extinction Length
Q_T, Q_i and Q_S are Total,
Intrinsic and Scattering Quality factors
H is the Heaviside step and δ is the Dirac's delta
W_0 is the Energy associated with the source

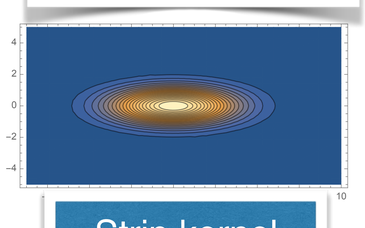


New coda attenuation kernels n-images

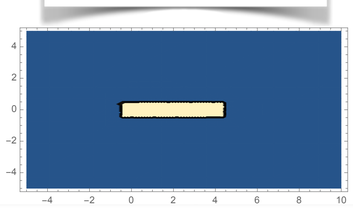


The novelty is the use of a new weighting function based on the Montecarlo numerical solution of the Energy Transport equation. A set of energy particles represent the seismic energy. They "scatter" (black circles) before reaching the receiver. The path space density is the intrinsic attenuation kernel (n_i). The scatterer space density is the scattering attenuation kernel (n_sc). The kernels are assumed to represent the weights of a space weighted average yielding the single Q-measurements.

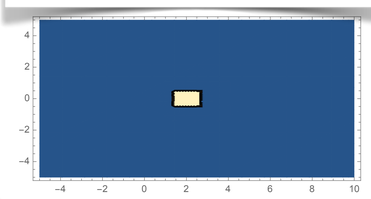
Gauss kernel g-images



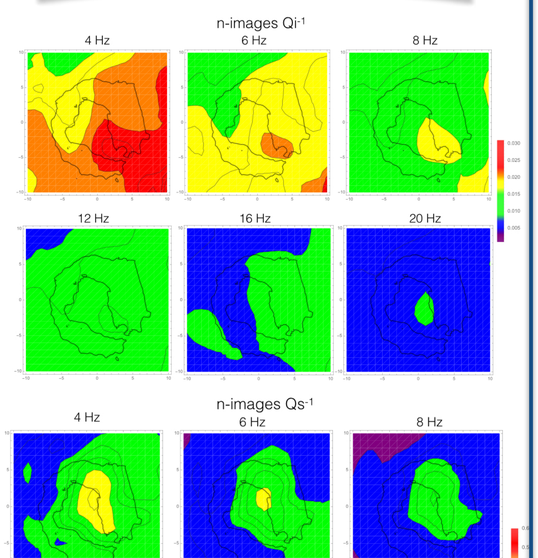
Strip kernel s-images



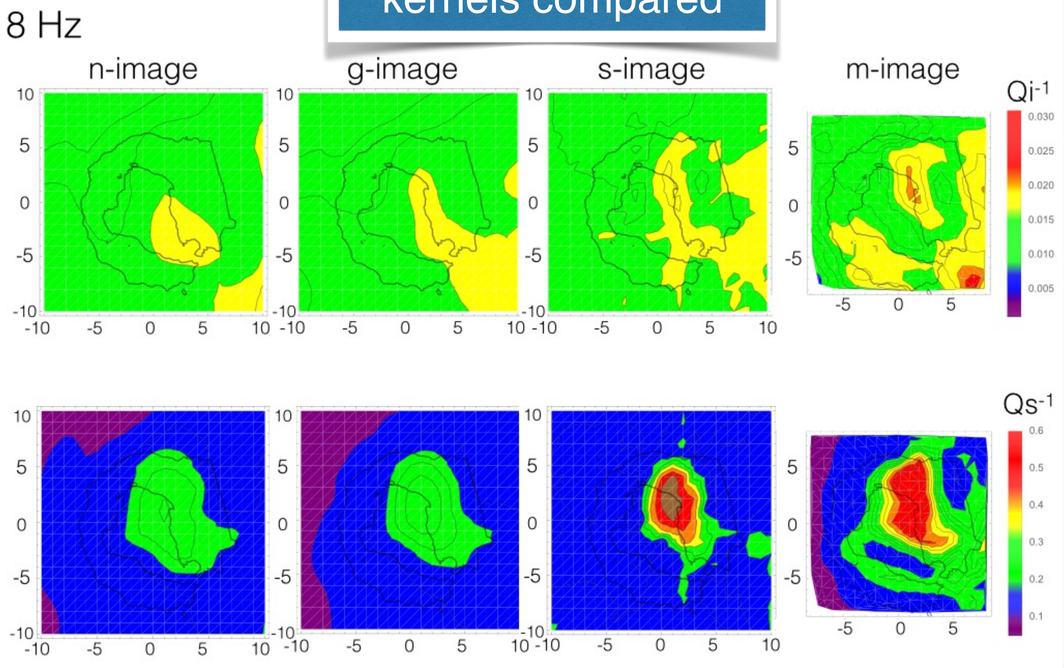
Mid-point kernel m-images



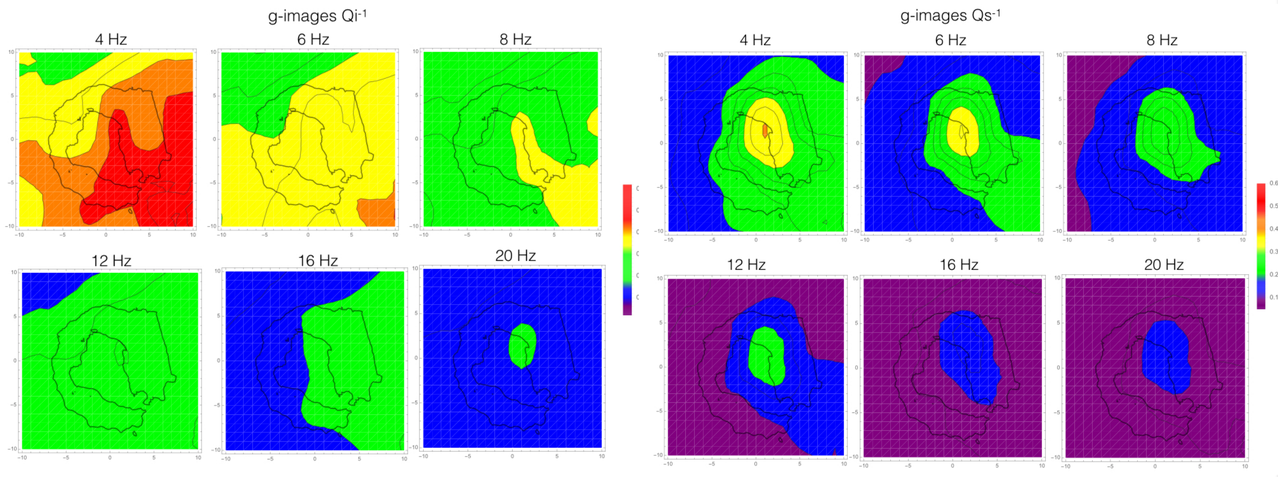
Tomographic Images New Kernel



Tomographic Images kernels compared



Tomographic Images Gauss Kernel



Acknowledgements. All calculations were made with Mathematica-10.
The authors are supported by MEDSUV European project, Spanish Project Project Ephestos, CGL2011-29499-C02-01 and Pon Project OPTOFER