



Journée technique CFMS/AGAP du 22 novembre 2019

**« *Regards croisés sur les méthodes de reconnaissance géotechnique et géophysique* »**

**Ondes sismiques de surface onshore/offshore  
et besoins géotechniques**

Nom de l'intervenant : Donatielle Leparoux (ifsttar)

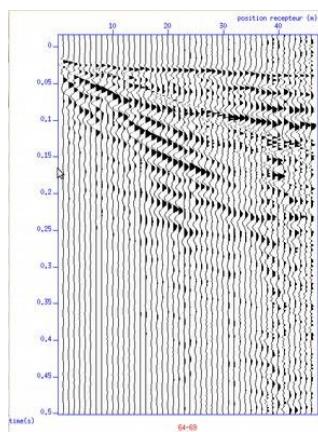
# Contenu

- Introduction : principle and key issues due to the assumptions
- Variability in the transverse direction : case of the sea-dike
- Variability in longitudinal direction : case of the near offshore
- Imaging a punctual heterogeneity : case of an underground cavity
- Conclusions

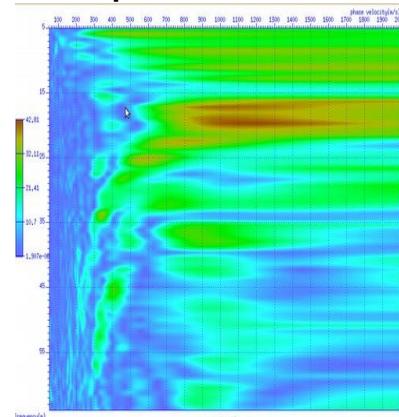
# Introduction

## Inversion of the Rayleigh Waves dispersion : Principle of usual methods

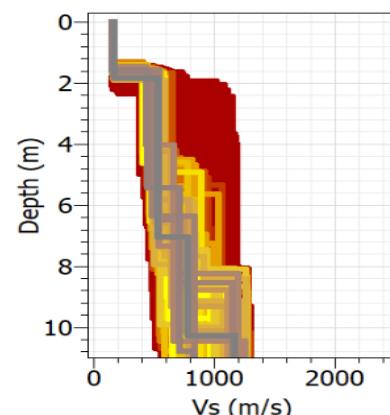
Seismic recording



Extraction of the dispersion curve



Inversion of the dispersion curve



Transformée p-w

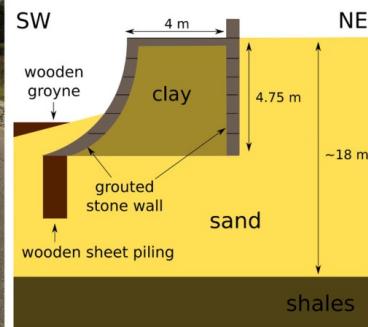
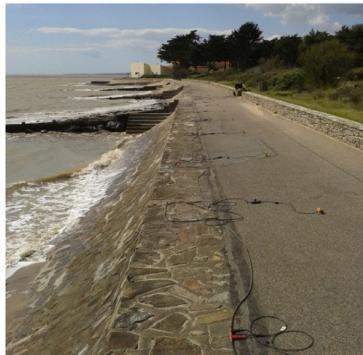
Pb inverse : Optimisation  
de la courbe de dispersion

# Introduction

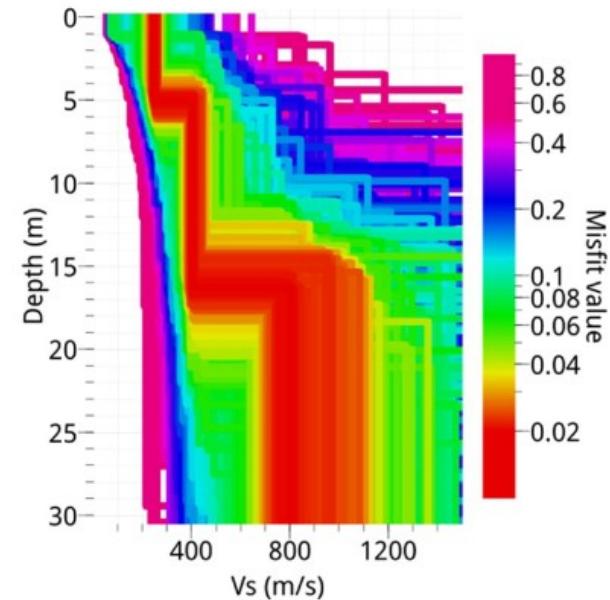
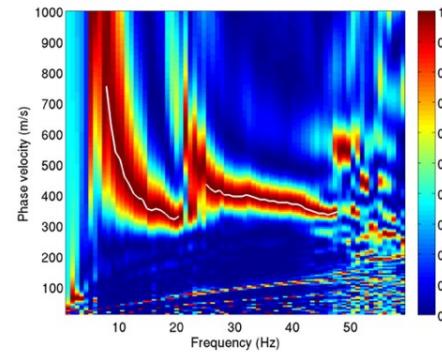
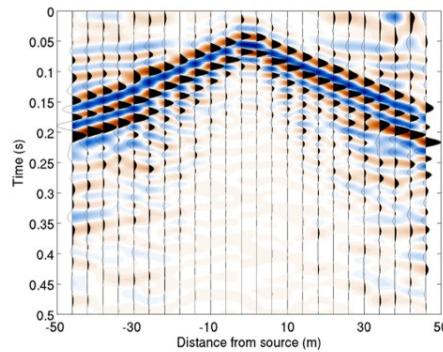
Principal key issues due to assumptions

- Assumption of a layered medium :
- →invariance in the transverse direction :  
case of levees and sea-dikes investigation
  - invariance in the longitudinal direction :  
case of 2D media as near offshore in french west coast
- Imaging punctual heterogeneities :  
case of underground cavities

# Variability in the transverse direction: case of levees and sea-dikes investigation



Example of real site : Les Moutiers en Retz, 44,Fr



Example of inverted results

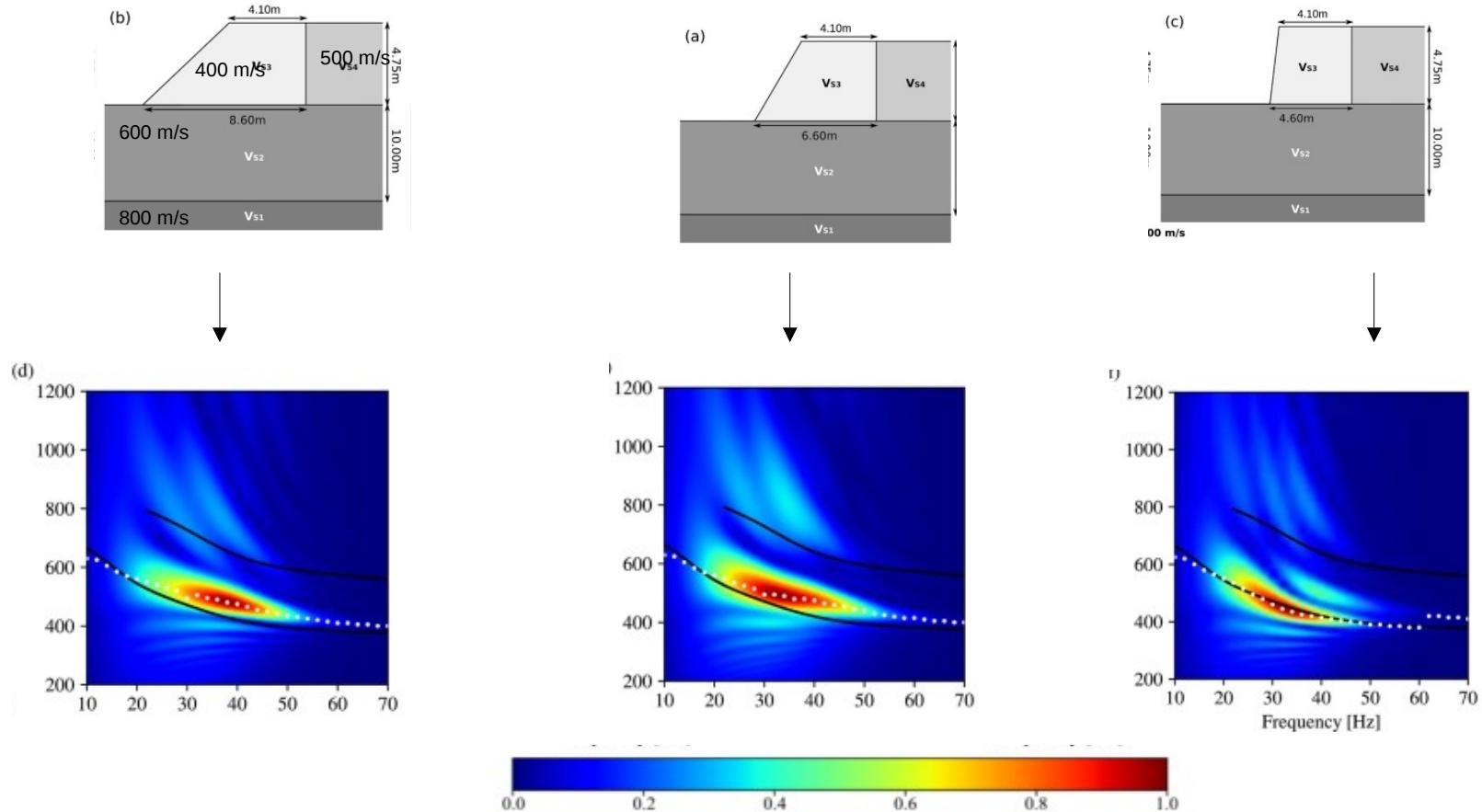
Example of seismic a shot gather and the extracted dispersion diagram

Le Feuvre et al., 2015, Passive multi-channel analysis of surface waves with cross-correlations and beamforming. Application to a sea dike, JAG 114 – 36-51.

JT CFMS/AGAP du 22/11/2019 – Reconnaissances géotechniques et géophysiques



# Variability in the transverse direction: case of levees and sea-dikes investigation



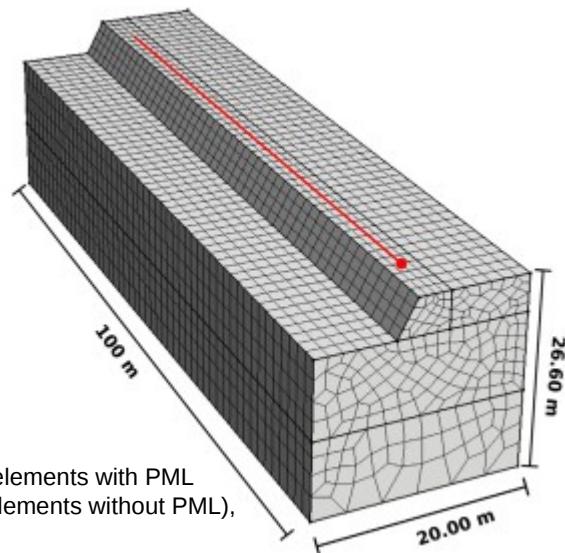
Pageot et al., 2020, Assessment of physical properties of a sea dike using MASW and 3D forward modeling, JAG 172–103841

JT CFMS/AGAP du 22/11/2019 – Reconnaissances géotechniques et géophysiques

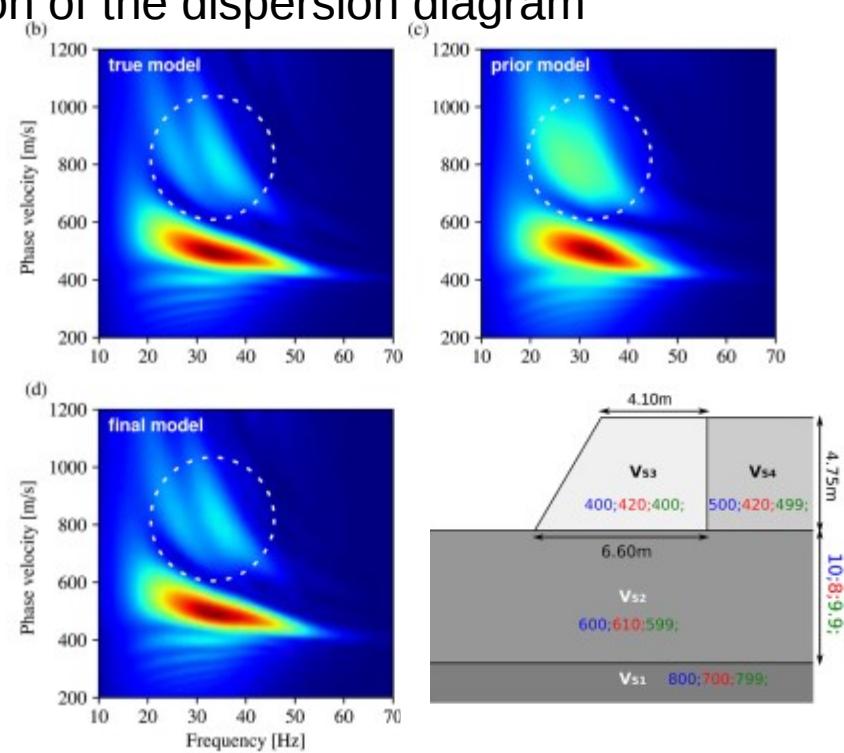
# Variability in the transverse direction: case of levees and sea-dikes investigation



Proposition (D. Pageot, VIBRIS Project) :  
3D Inversion through local optimization of the dispersion diagram



Numerical modelling with SEM  
The meshing is adapted to the model of each direct problem



Results - blue : the real value ; red : the initial value; green : the inverted value

# Variability in the transverse direction: case of levees and sea-dikes investigation



Proposition :

3D Inversion through local optimization of the dispersion diagram

- The dispersion diagram with superior modes is entirely taken into account
- The 3D geometry is taken into account
- The results accuracy is greater in term of velocity as well as interfaces depth
- Lateral Information is retrieved

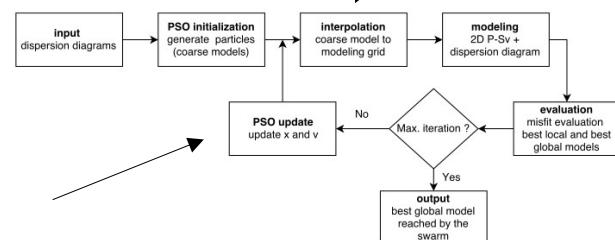
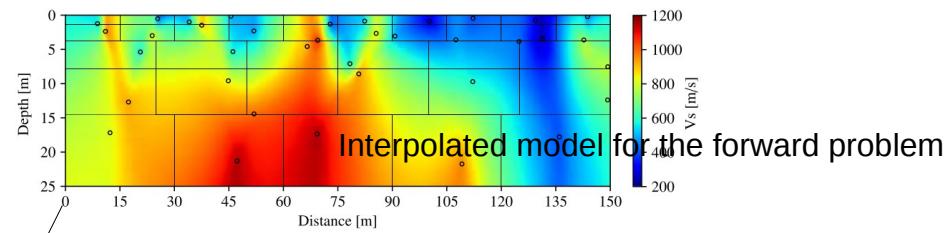
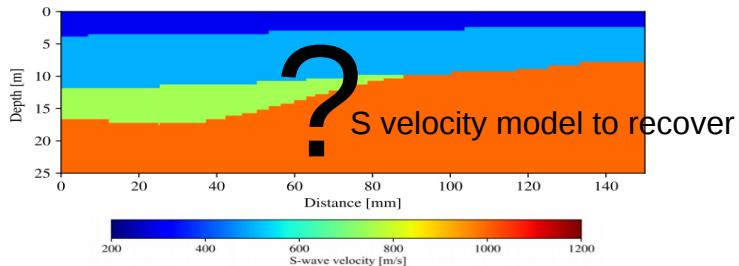
*Pageot et al., 2020, Assessment of physical properties of a sea dike using MASW and 3D forward modeling, JAG 172–103841*

# Variability in the longitudinal direction:

case of near offshore underground media,  
west french coast



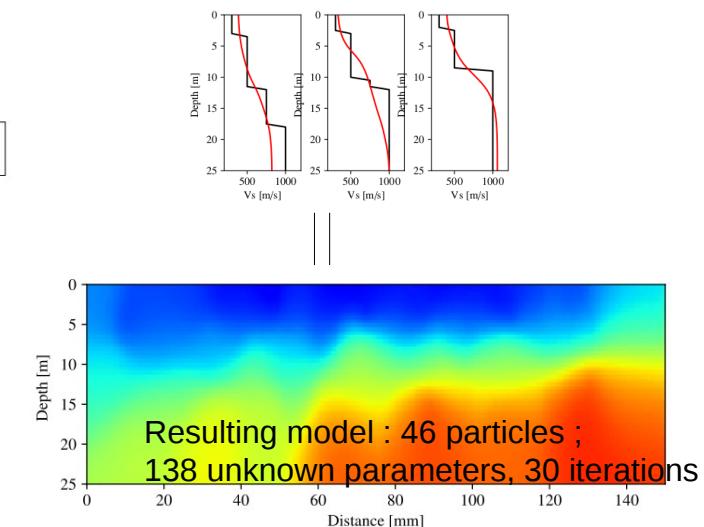
Proposition (D. Pageot PROSE Project) :  
2D Inversion using (Global) Particle Swarm Optimization of the diagram



$$v_i^{k+1} = \chi \left[ v_i^k + c_1 r_1 (p_i - x_i^k) + c_2 r_2 (p_g - x_i^k) \right]$$

$$x_i^{k+1} = x_i^{k+1} + \xi v_i^{k+1}$$

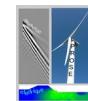
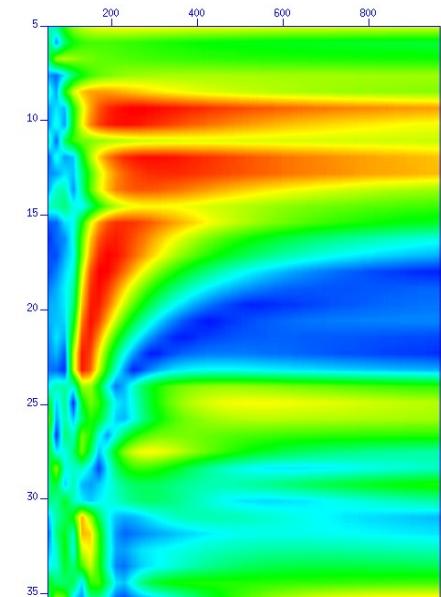
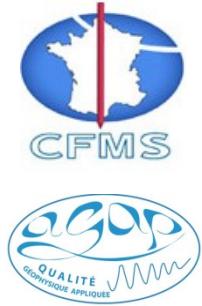
Formulation of the updated parameter through  
Swarm Particles Optimization



# Variability in the longitudinal direction:

case of near offshore underground media,  
west french coast

First measurement in “Golf du Morbihan”, Fr

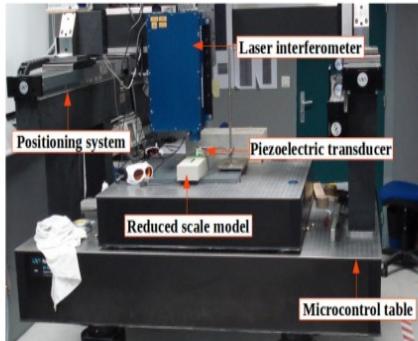
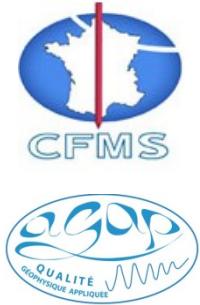


**SIG** Bureau d'études

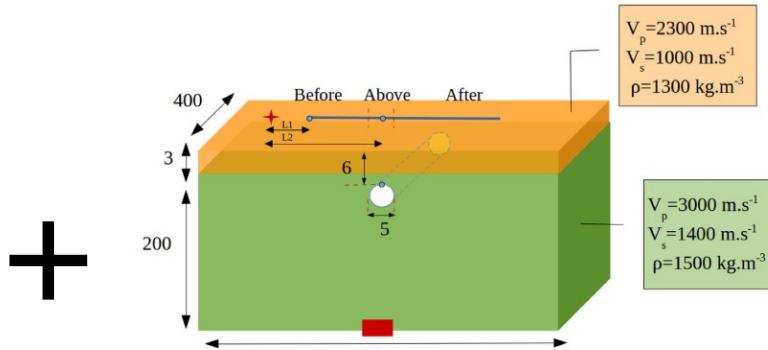
JT CFMS/AGAP du 22/11/2019 – Reconnaissances géotechniques et  
géophysiques



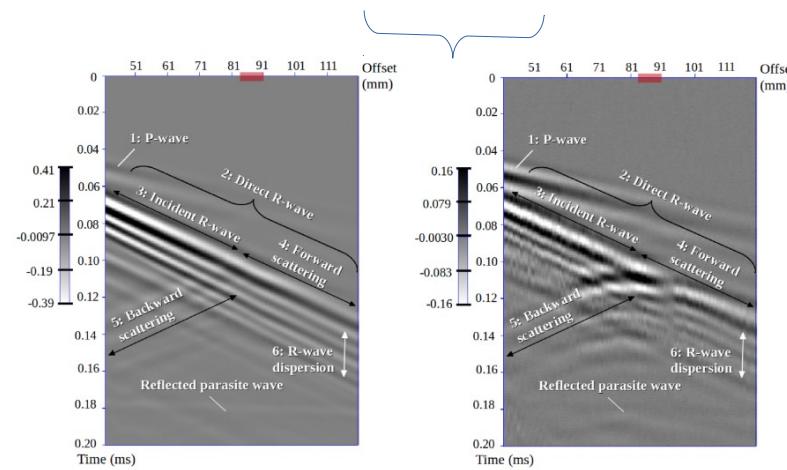
# Imaging a punctual heterogeneity: case of underground cavities



MUSC Bench for reduced scale experimentation



Resine Model

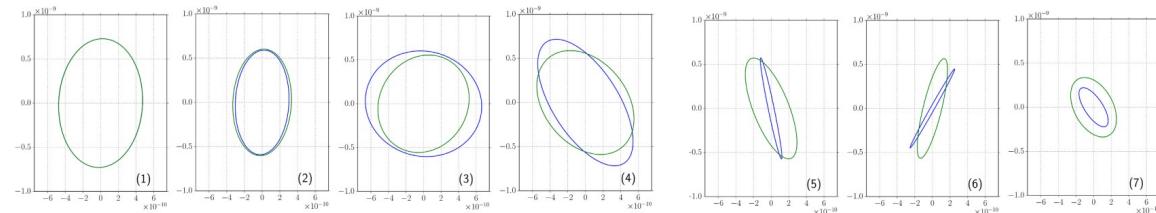


Seismic shot gather for the vertical and horizontal components

Filippi et al., 2019, New robust observables on Rayleigh waves affected by an underground cavity: from numerical to experimental modelling. *GJI*, 218(3), 1903-1918.

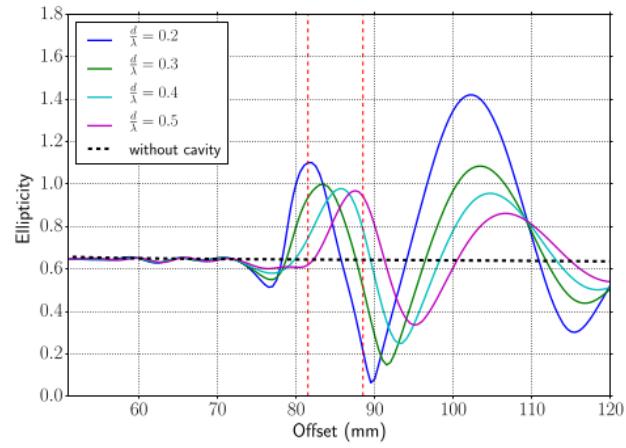
JT CFMS/AGAP du 22/11/2019 – Reconnaissances géotechniques et géophysiques

# Imaging a punctual heterogeneity: case of underground cavities

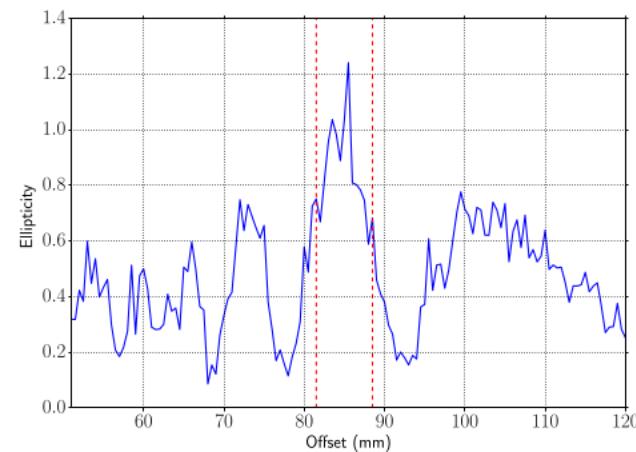


Modification de l'ellipticité due à la présence de la cavité

Simultaion  
Numerique  
Pour différentes  
profondeurs de  
cavités



Anomalie H/V en fonction de la position par rapport à la cavité



Réultat  
expérimental

Filippi et al., 2019, New robust observables on Rayleigh waves affected by an underground cavity: from numerical to experimental modelling. GJI, 218(3), 1903-1918.

# Conclusions

- Variability in the transverse direction : case of the sea-dike
  - Improving the results by taking 3D geometry and dispersion diagram inversion
- Variability in longitudinal direction - case of the near offshore
  - Recovering the 2D Vs medium through PSO to invert the dispersion diagram
- Imaging a punctual heterogeneity - case of an underground cavity :
  - Assessing the cavity depth position with the H/V observable
- RMQ : Need of field data tests → in progress