



Adaptive inverse methods for seismo-acoustic events analysis

JDD GRNE 2024

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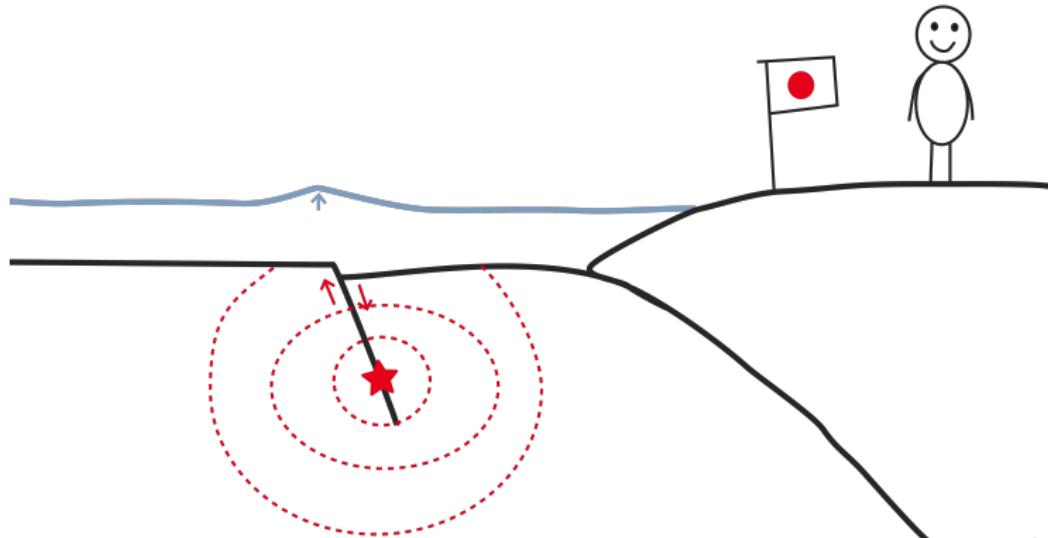
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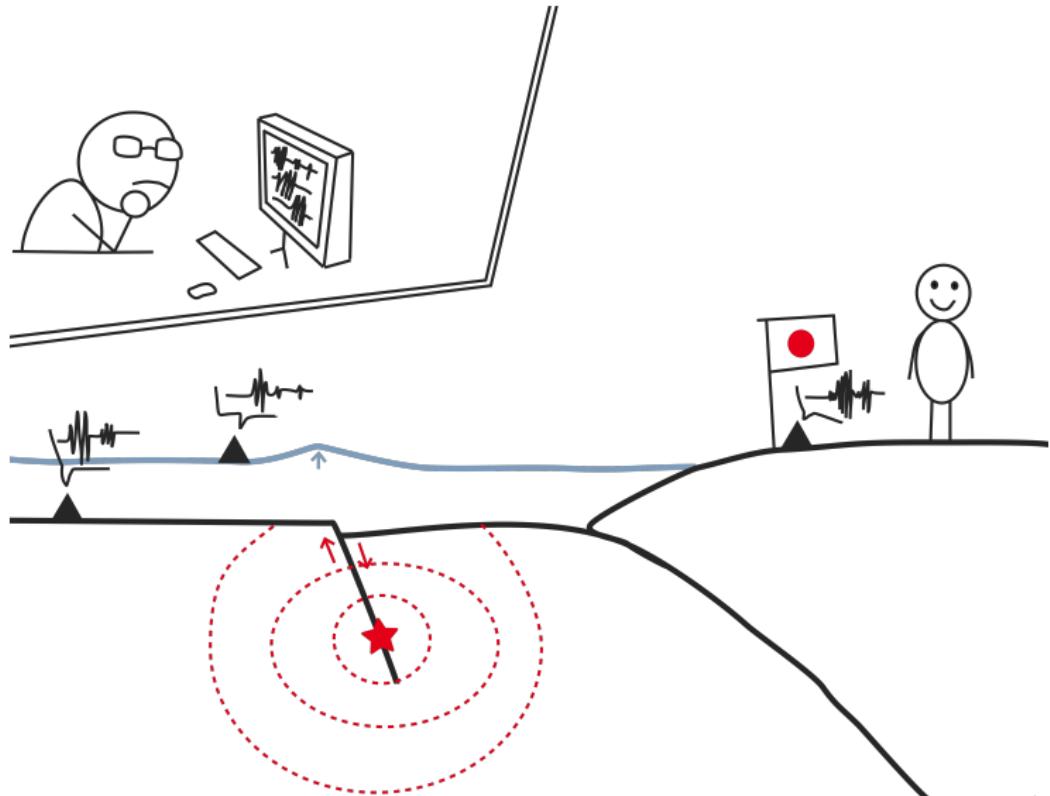
Context

- Imagine...



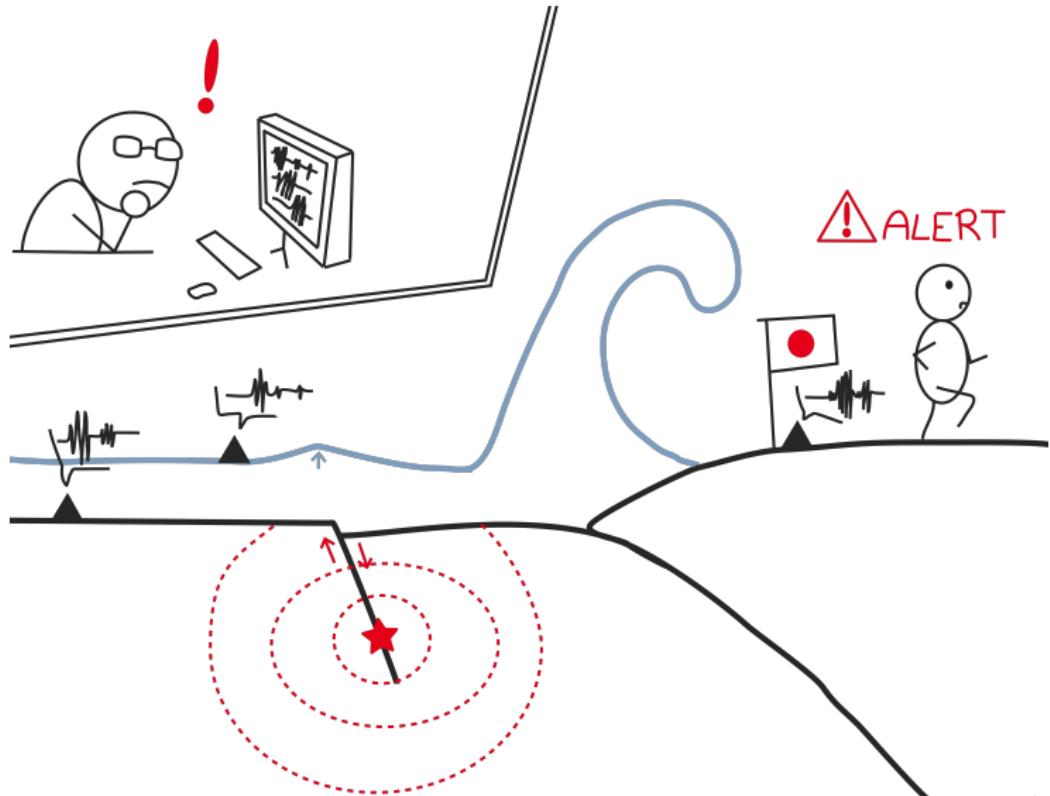
Context

- Monitoring system → analyze earthquake events



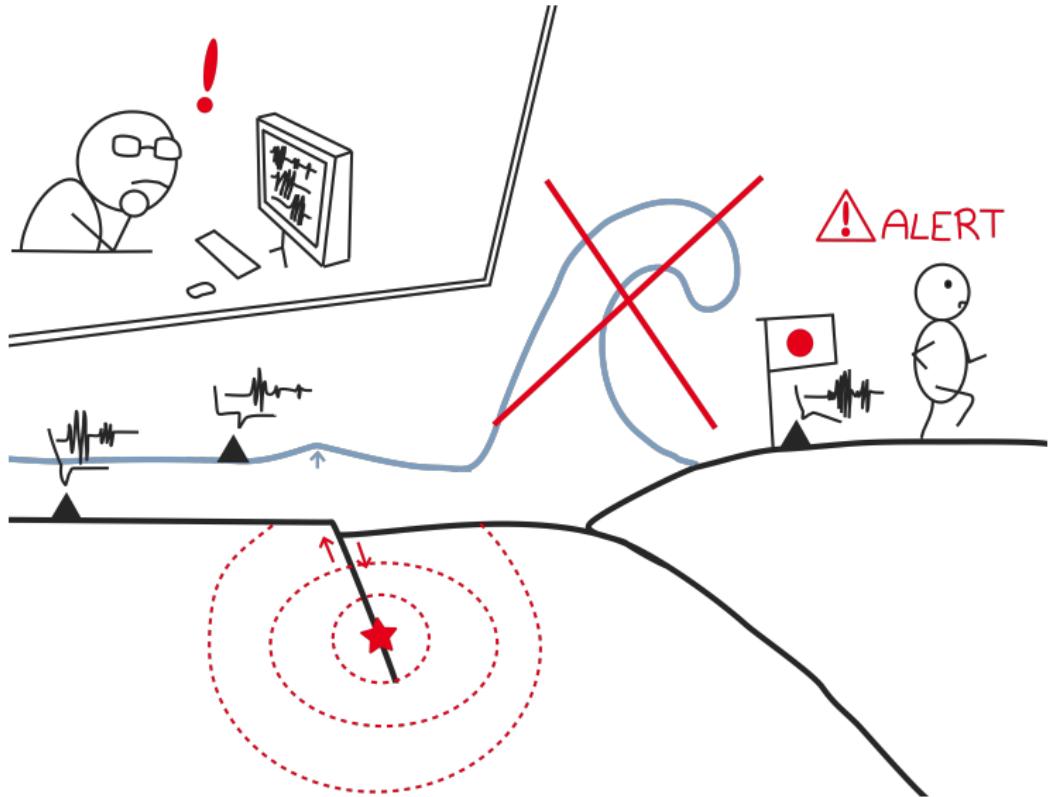
Context

- Tsunami prevention



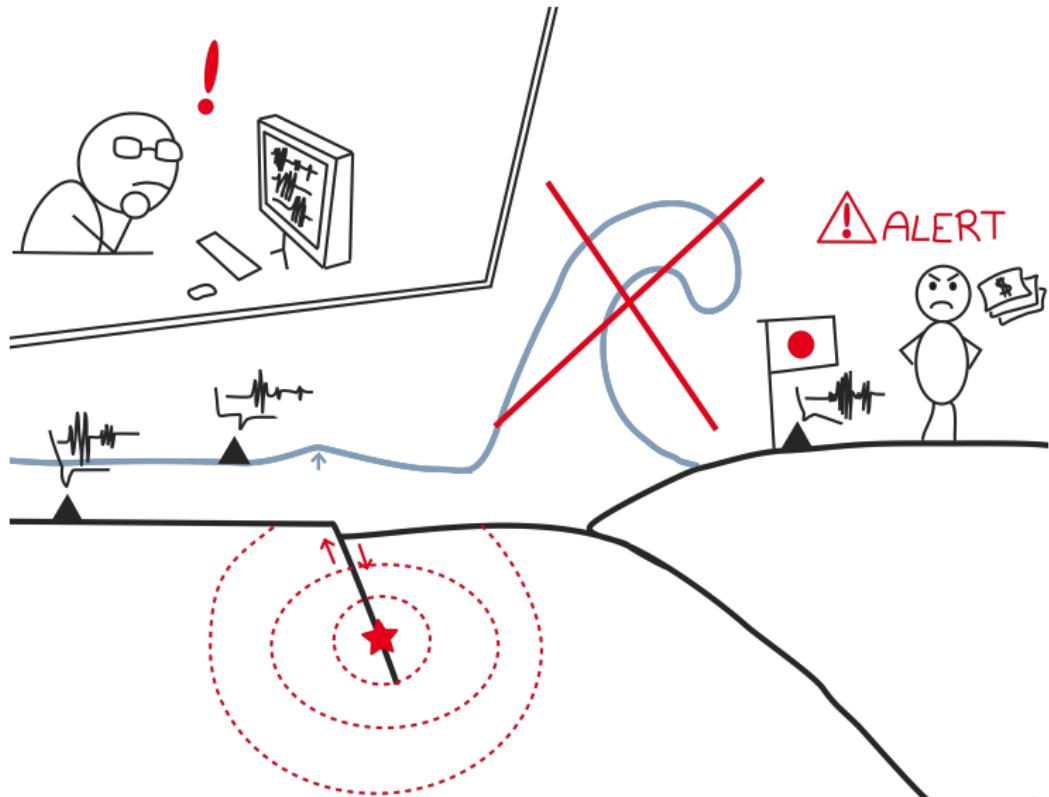
Context

- False Positive



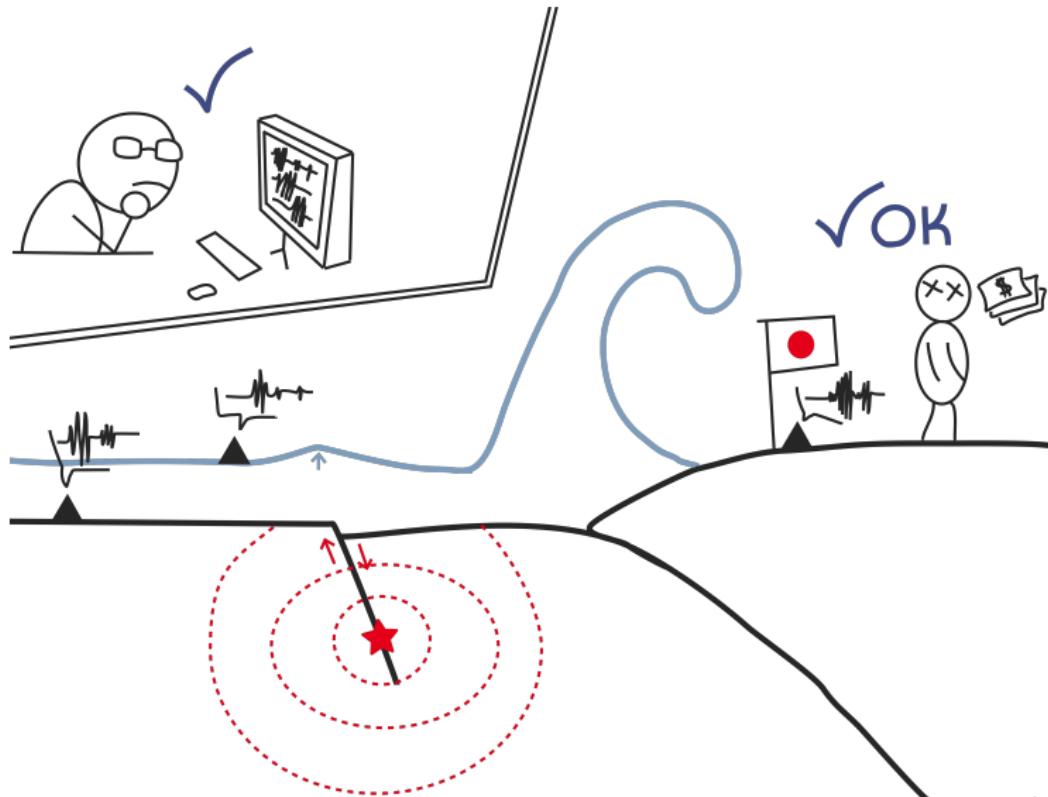
Context

- False Positive → Money and trust loss



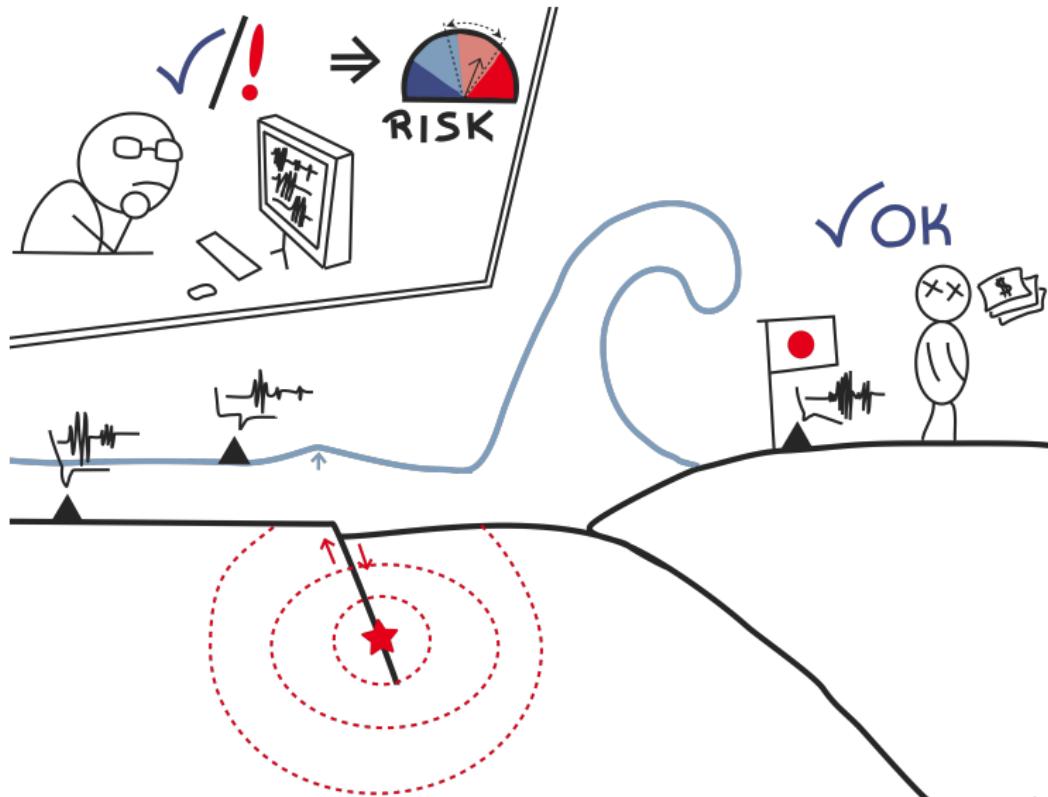
Context

- False Negative → Money loss and deaths



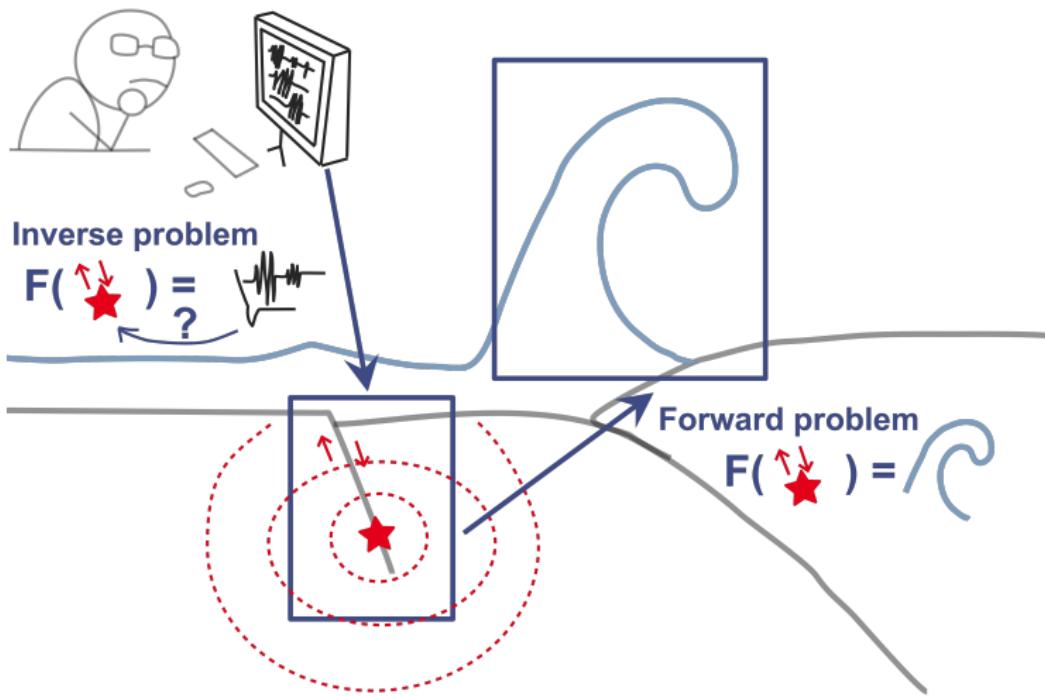
Context

- Necessity to *quantify uncertainty*



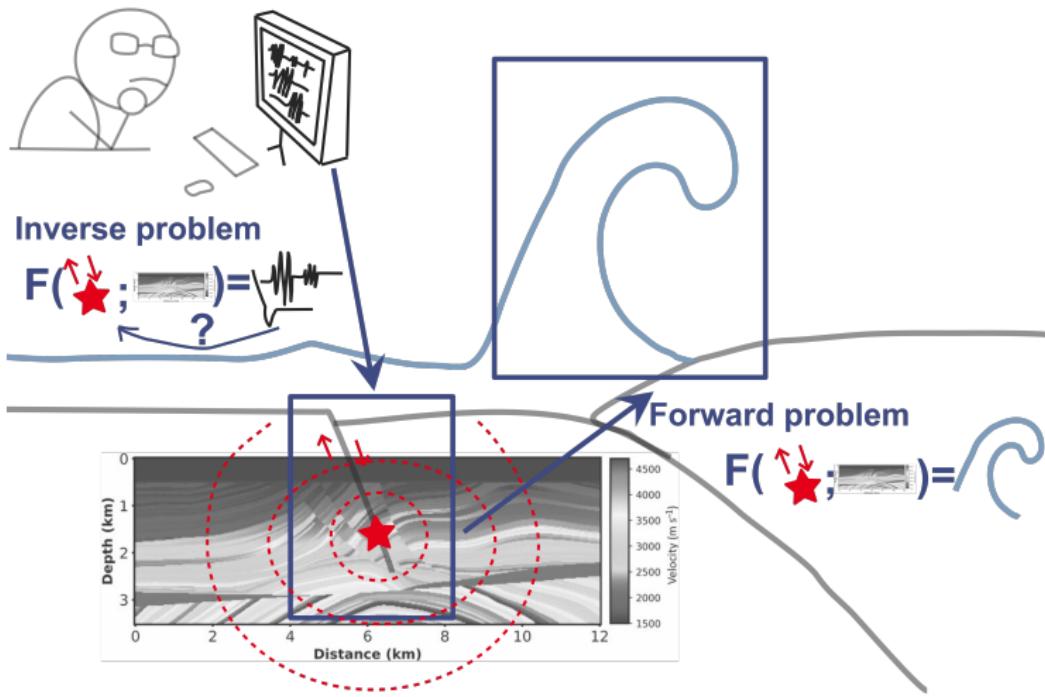
Initial problem

- Data → Source parameters → Simulation



Initial problem

- Data → Source parameters → Simulation
- Poorly known parameters, e.g. the velocity field



Inverse problem

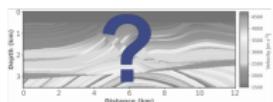
- Search for the velocity fields that correspond to the observations



Seismic tomography problem

$$F(\overset{\uparrow}{\star} ; \quad ; \quad \underset{?}{\text{---}} \quad) = \text{---}$$

The equation illustrates the seismic tomography problem. On the left, a red star with upward-pointing arrows is followed by a semi-colon, another semi-colon, and a question mark inside a dashed rectangle. To the right of the question mark is an equals sign, followed by a seismic wavelet showing multiple reflections and a vertical line with a spring symbol at its end.

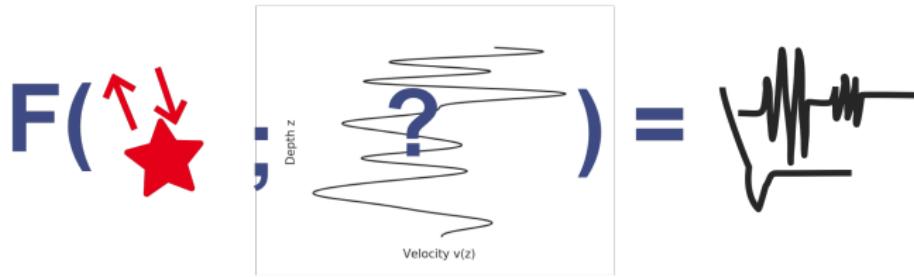


Inverse problem

- Search for the 1D velocity fields that correspond to the observations



Seismic tomography problem

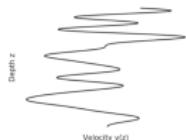


Markov Chain Monte Carlo algorithm

- Iteratively test fields
- Converge to the field *posterior distribution*: probable fields according to the observations

Propose a field

$$F(\star; \quad)$$



vs

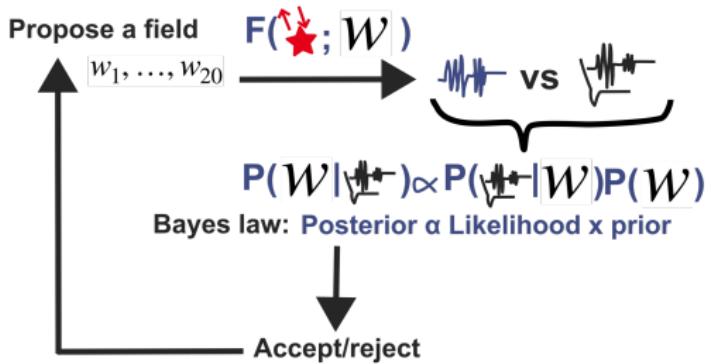
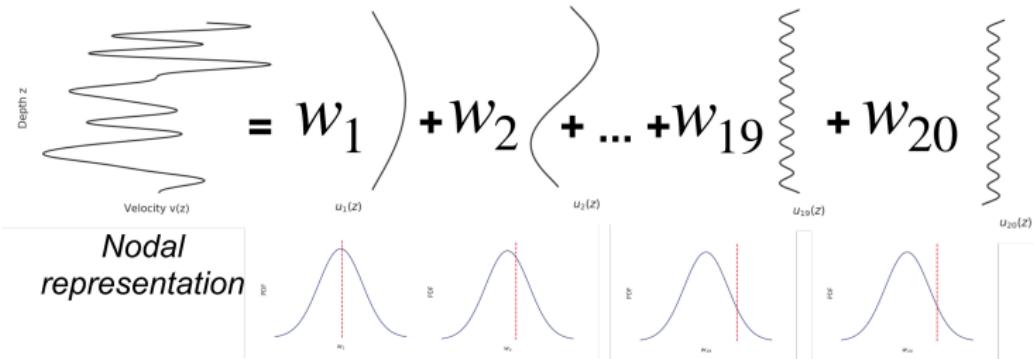


$$P(\quad | \quad) \propto P(\quad | \quad) P(\quad)$$

Bayes law: Posterior \propto Likelihood \times prior

Accept/reject

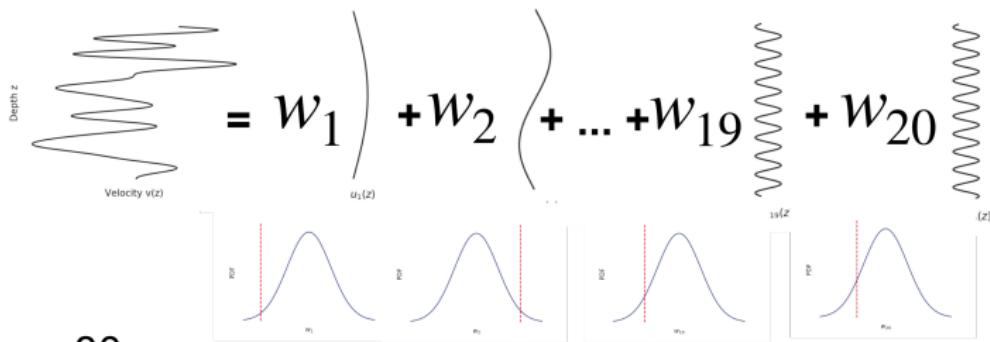
Modal representation [Marzouk, 2007]



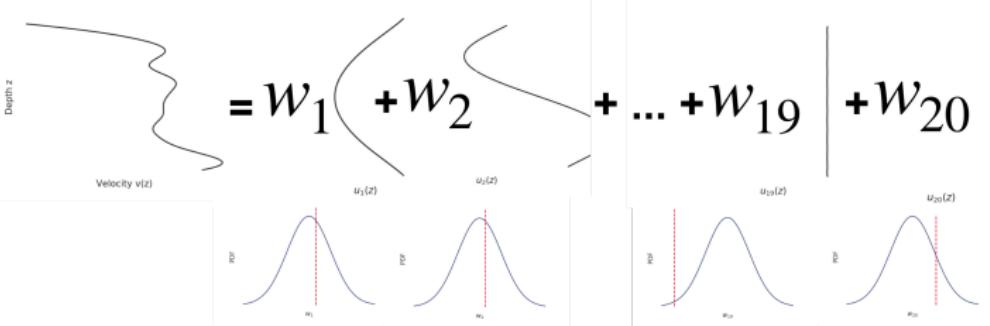
Hyperparameter influence



$q=10$



$q=80$

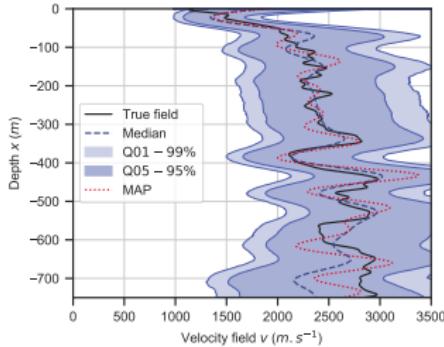


First results

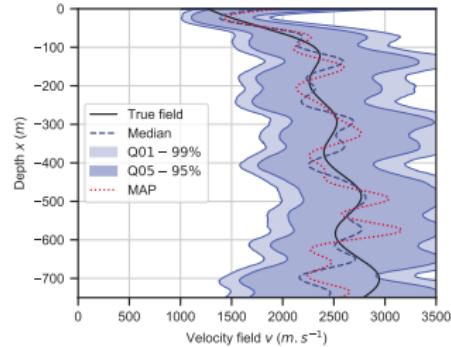


$q = 10$

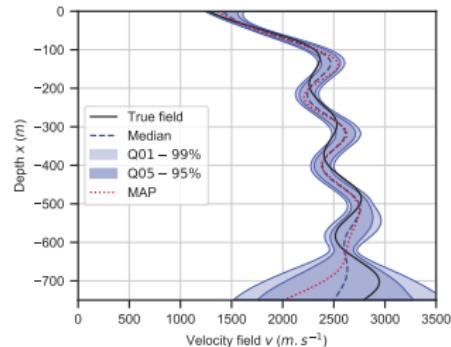
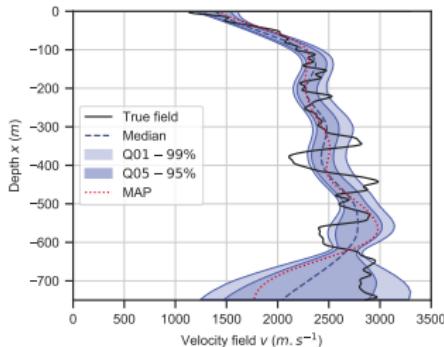
SW field



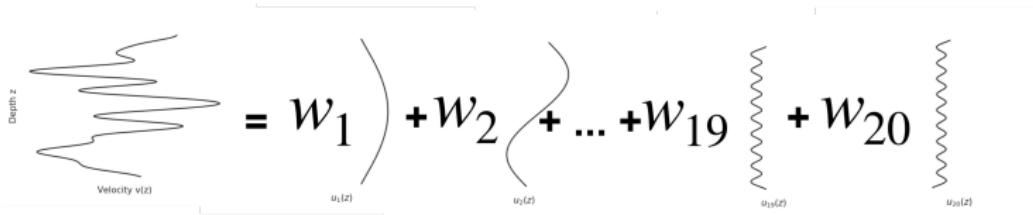
LW field



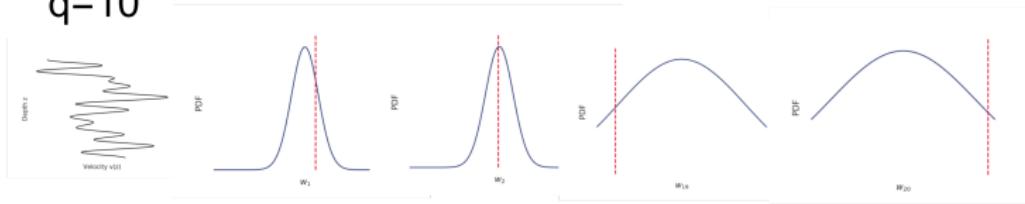
$q = 80$



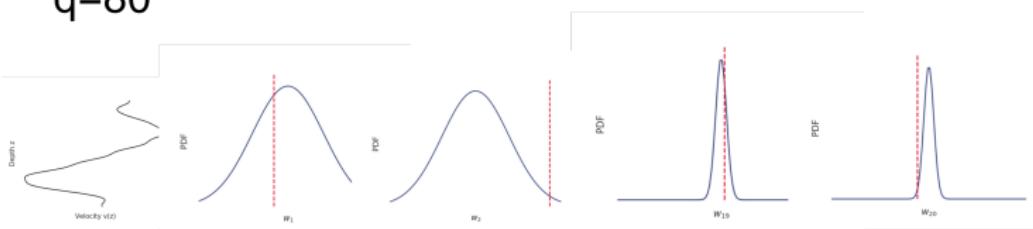
Change of measure



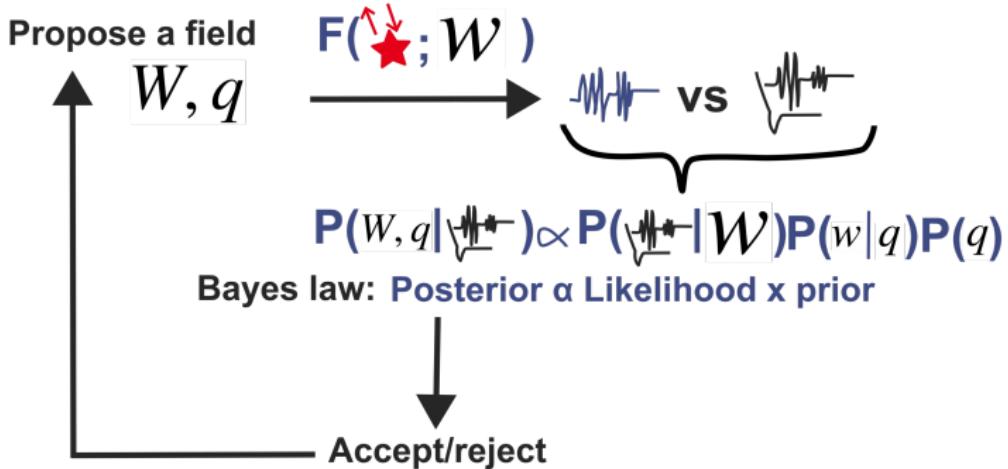
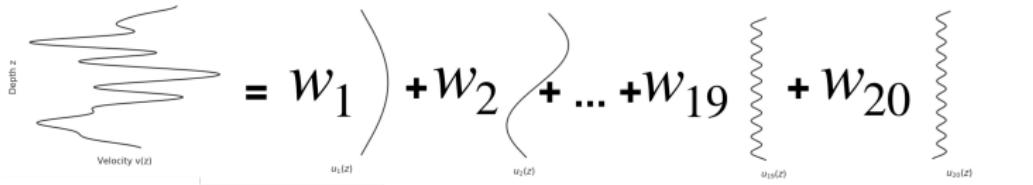
$q=10$



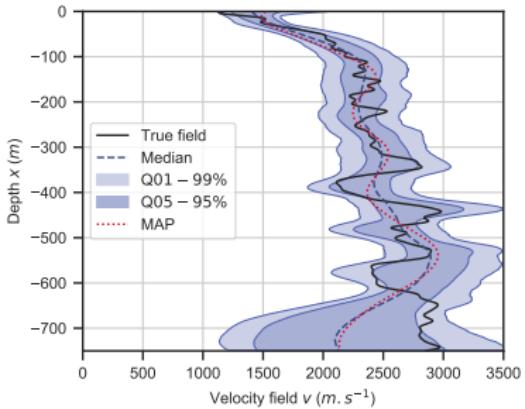
$q=80$



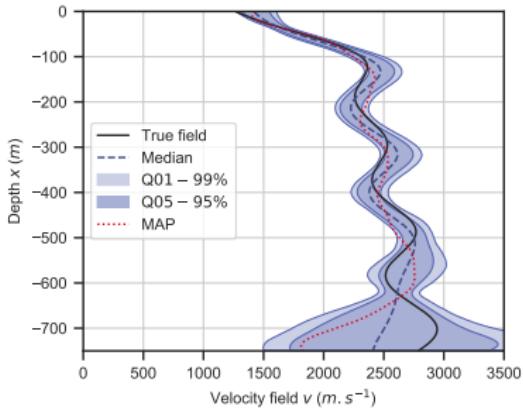
Change of measure inference



Final results



(a) SW field, CoM



(b) LW field, CoM

- the CoM allows distinguishing the two fields behavior

Conclusion



- Risk prevision needs *uncertainty quantification*
- *Ground properties* are badly known
- New *parametrization* of the velocity field
- Reduction of the *prior influence*

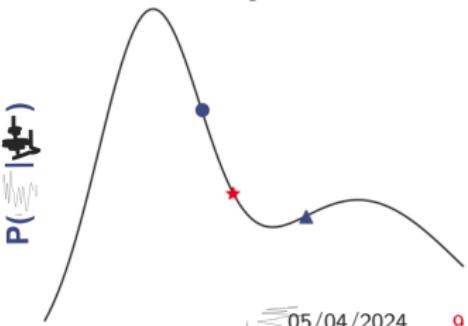
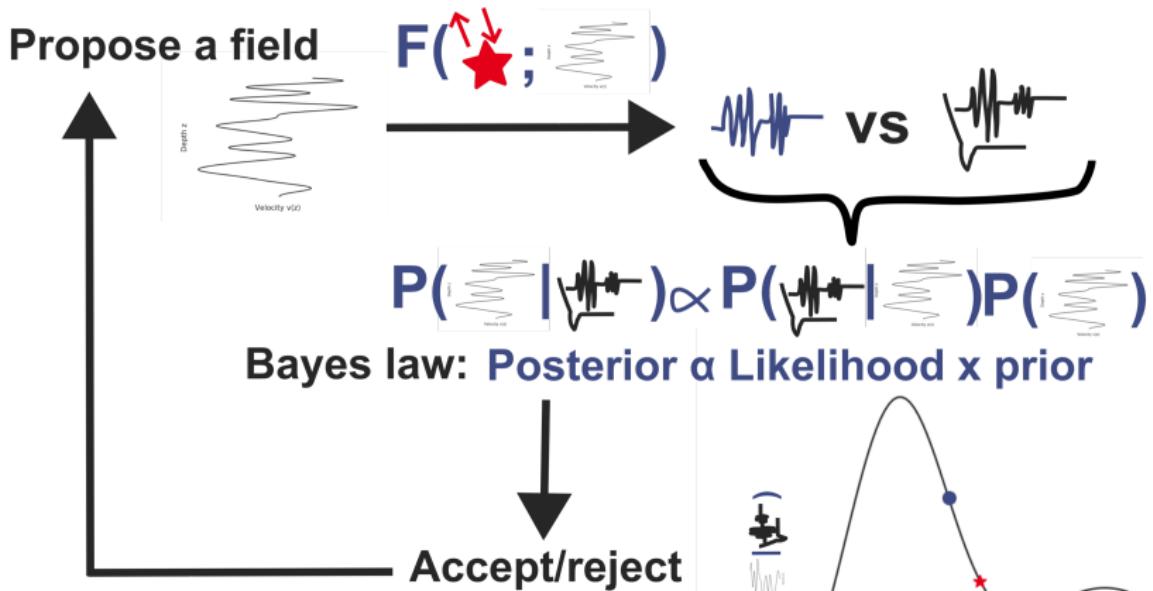
Thank you !

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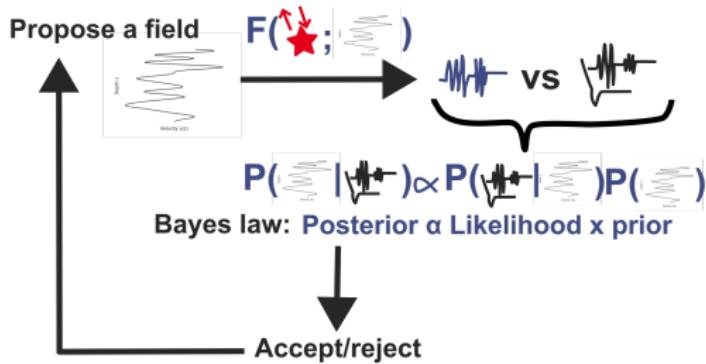
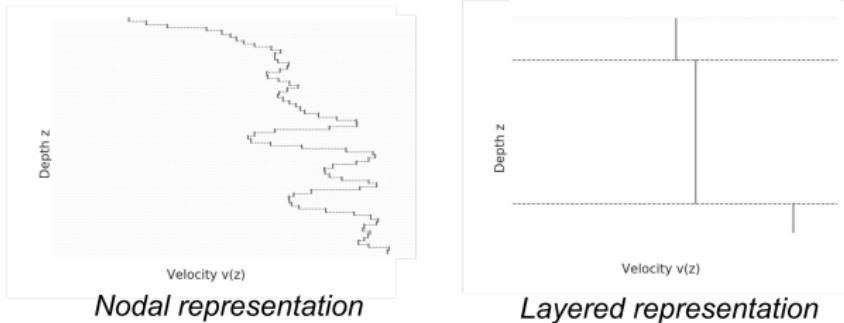
*Keywords: Seismic tomography, Inverse problem,
Uncertainty quantification, Dimension reduction*

Markov Chain Monte Carlo algorithm

- If the field is more probable: save it
- Else: save only with a certain probability → avoid to get stuck



Field parametrization



Hyperparameter inference

