



Adaptive inverse methods for seismo-acoustic events analysis

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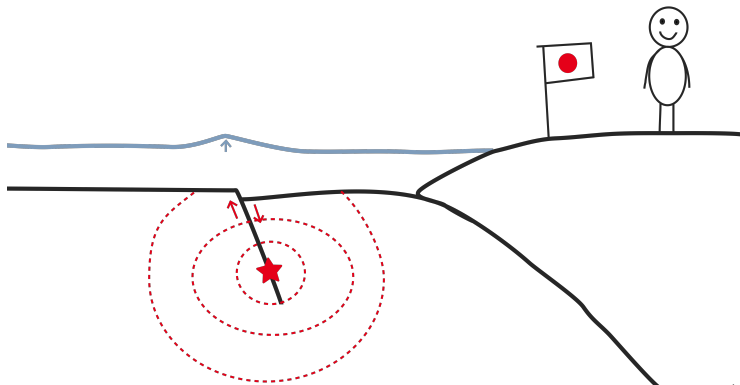
² Mines Paris PSL, Fontainebleau

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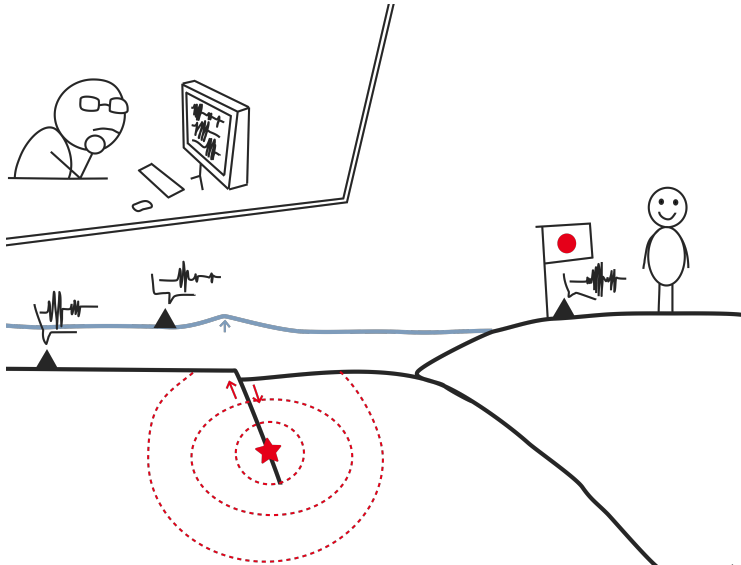
Context

- Imagine...



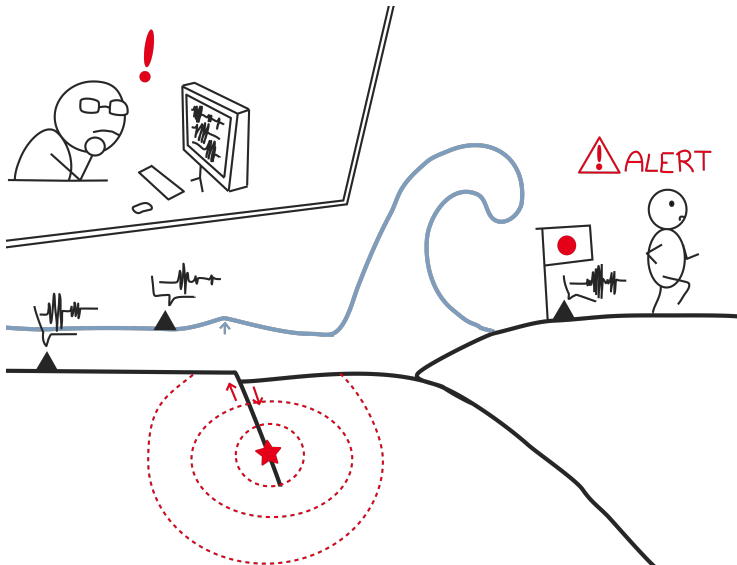
Context

- Monitoring system → analyze earthquake events



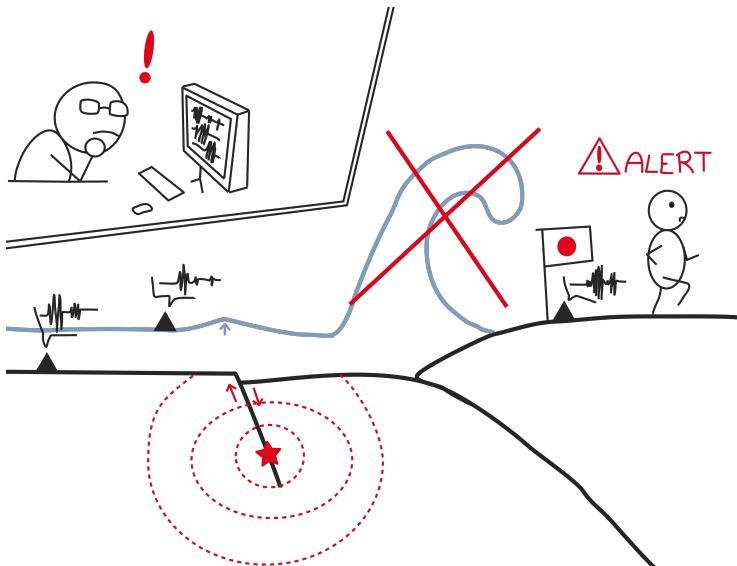
Context

- Tsunami prevention



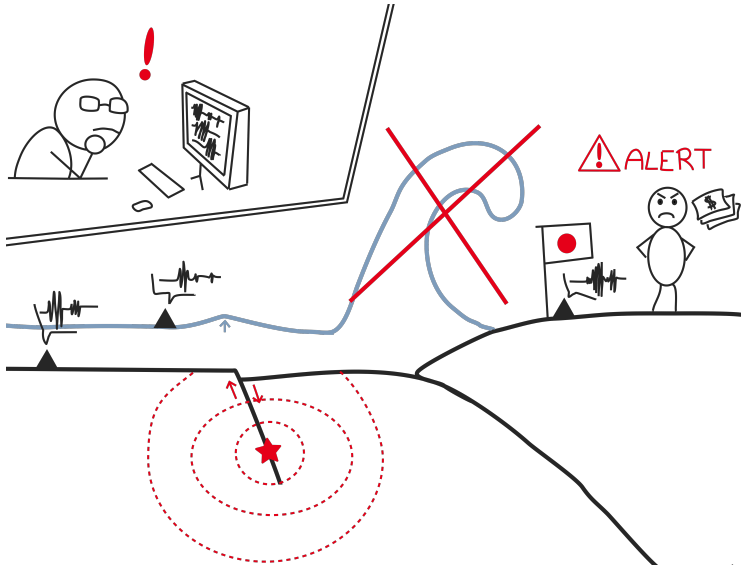
Context

- False Positive



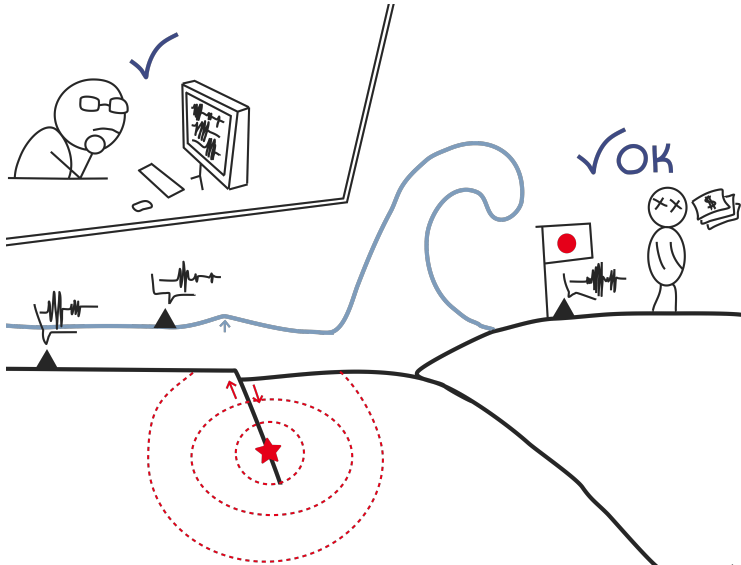
Context

- False Positive → Money and trust loss



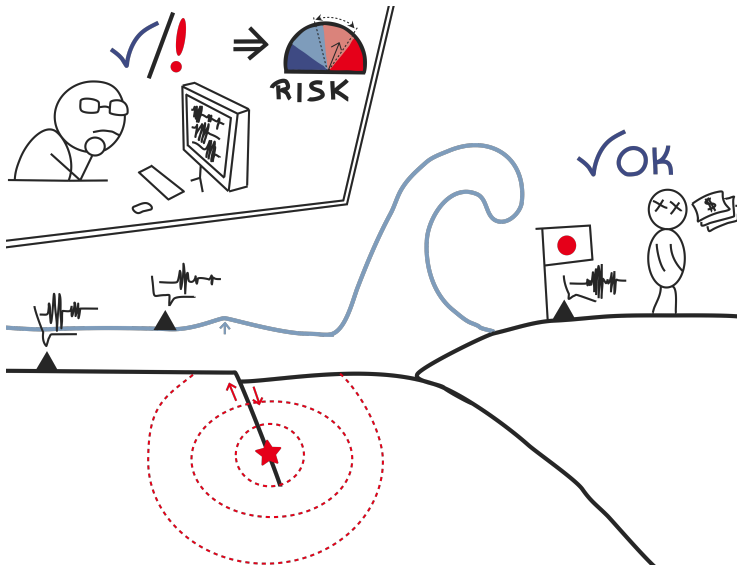
Context

- False Negative → Money loss and deaths



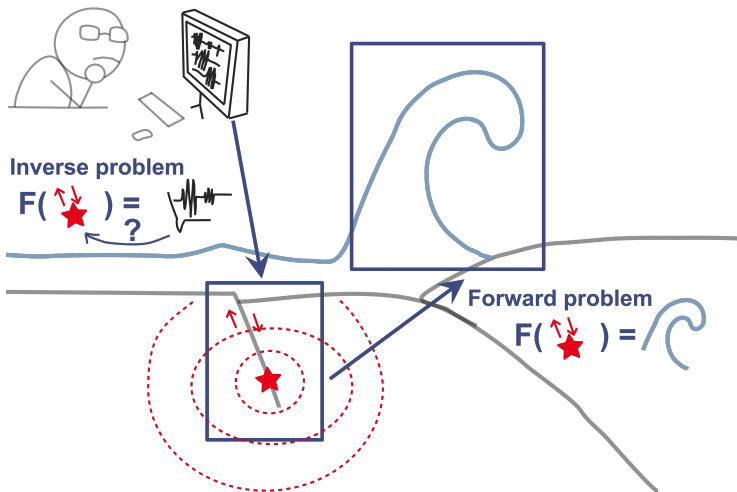
Context

- Necessity to *quantify uncertainty*



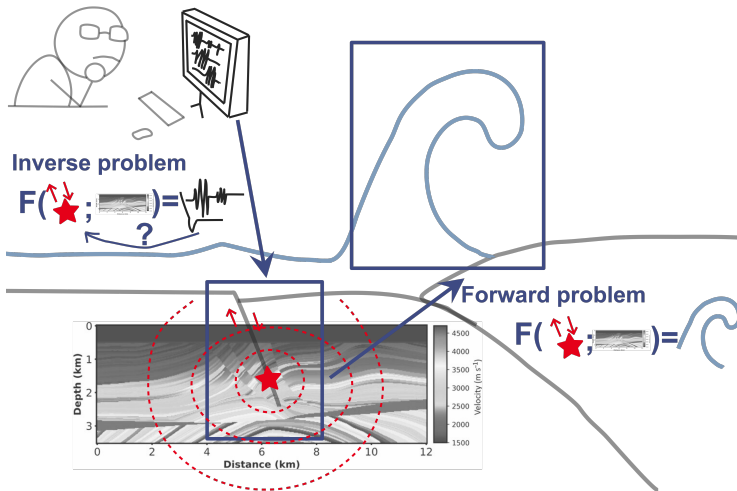
Initial problem

- Data → Source parameters → Simulation



Initial problem

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



Inverse problem

- Search for the velocity fields that correspond to the observations

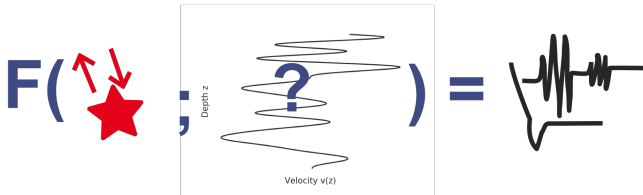
Seismic tomography problem

$$F(\text{star with arrows}; \text{tomography plot with ?}) = \text{seismic waveform}$$

Inverse problem

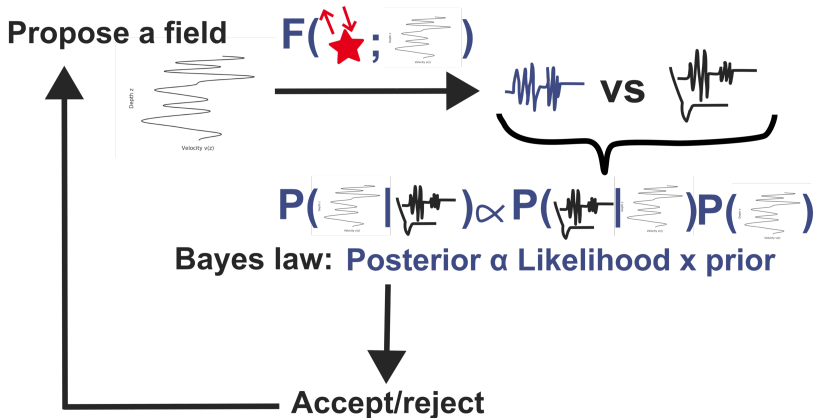
- Search for the 1D velocity fields that correspond to the observations

Seismic tomography problem

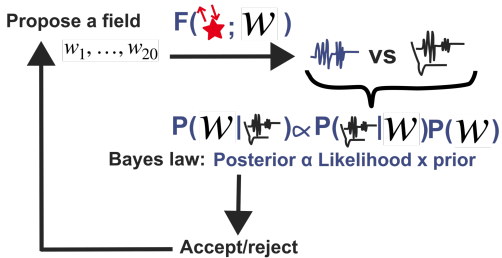
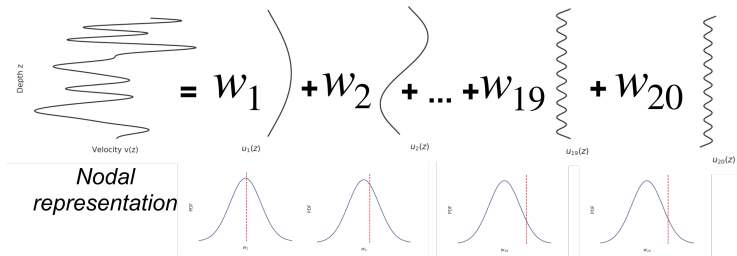


Markov Chain Monte Carlo algorithm

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



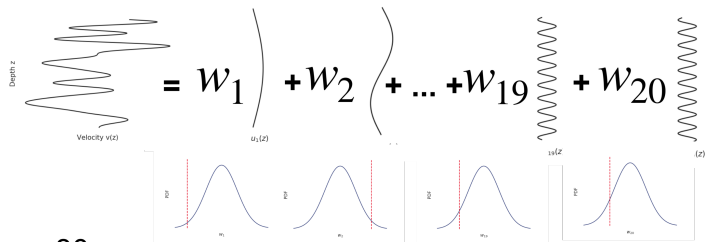
Modal representation [Marzouk, 2007]



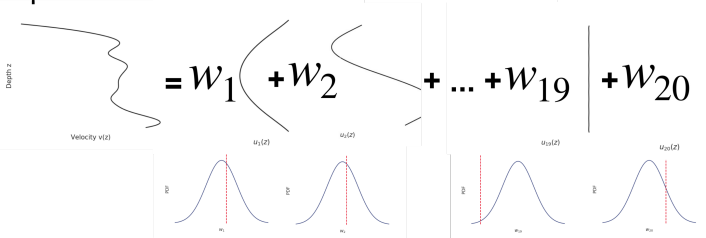
Hyperparameter influence



q=10



q=80

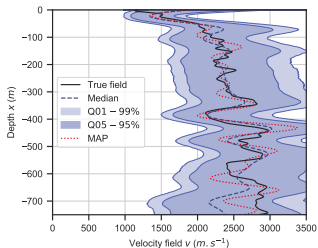


First results

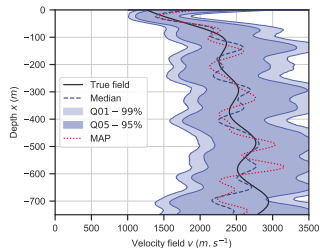


$q = 10$

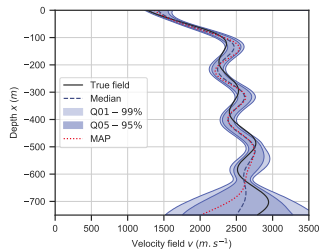
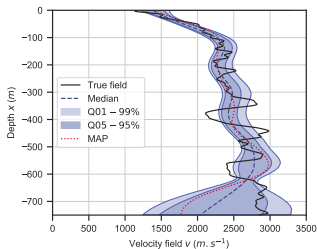
SW field



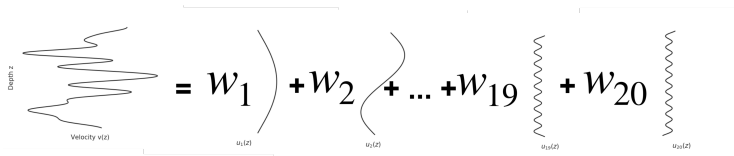
LW field



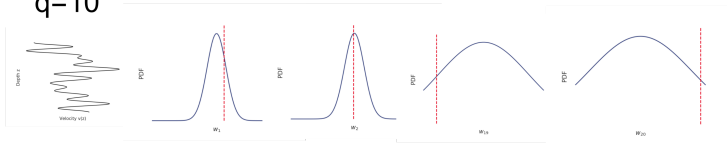
$q = 80$



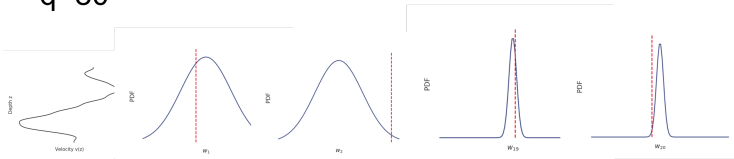
Change of measure



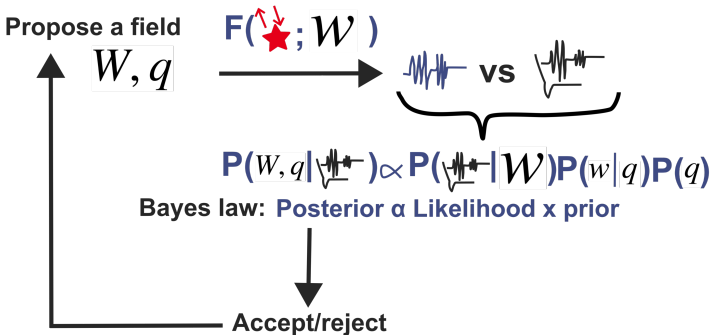
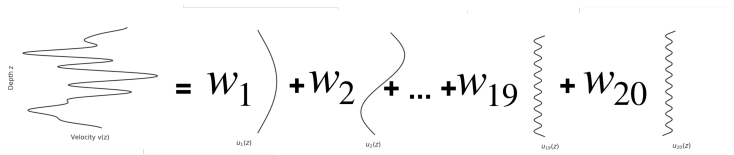
$q=10$



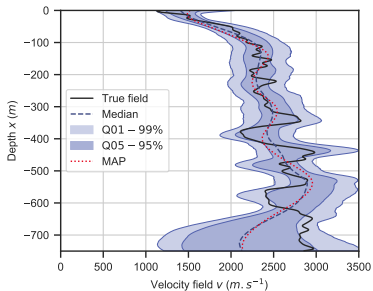
$q=80$



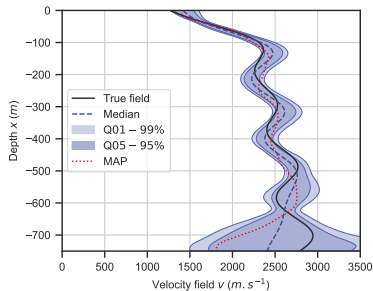
Change of measure inference



Final results



(a) SW field, CoM



(b) LW field, CoM

- the CoM allows distinguishing the two fields behavior

Conclusion

⚠️ ALERT



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

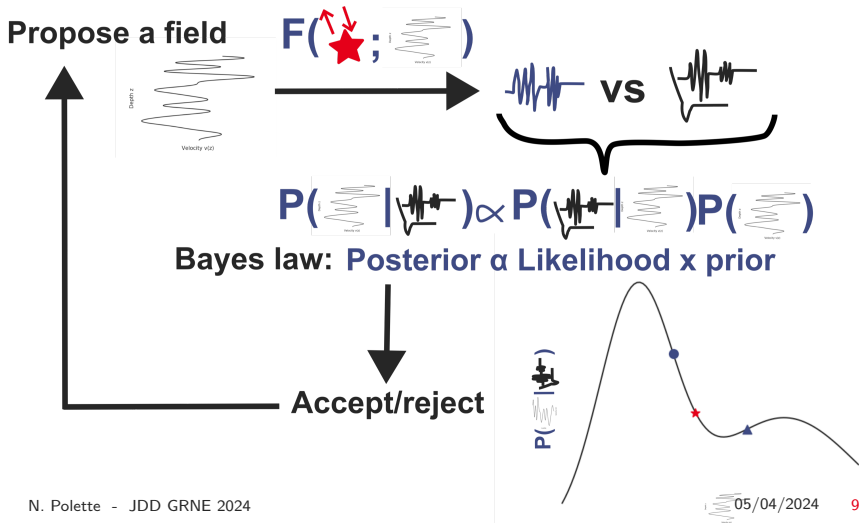
Thank you !

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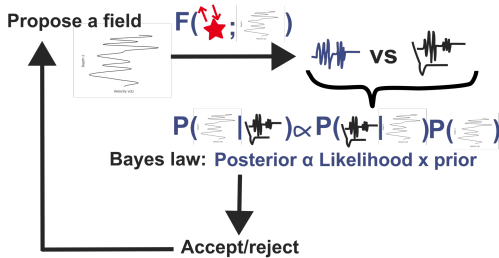
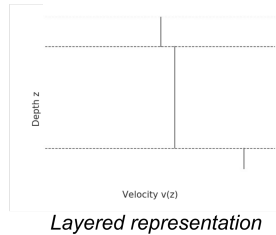
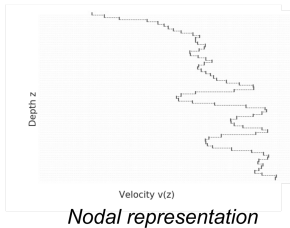
Keywords: Seismic tomography, Inverse problem, Uncertainty quantification, Dimension reduction

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

